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(54) **Organic light emitting device and flat panel display device comprising the same**

(57) Provided are an organic light emitting device including: a substrate; a first electrode; a second electrode; and an organic layer interposed between the first electrode and the second electrode and including an emission layer, wherein one of the first electrode and the second electrode is a reflective electrode and the other is a semitransparent or transparent electrode, and wherein the organic layer includes a layer having at least one of

the compounds having at least one carbazole group, and a flat panel display device including the organic light emitting device. The organic light emitting device has low driving voltage, excellent current density, high brightness, excellent color purity, high efficiency, and long life-time.

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Description

[0001] This application claims the benefit of Korean Patent Application No. 10-2006-0048306, filed on May 29, 2006, in the Korean Intellectual Property Office.

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0002] The present invention relates to an organic light emitting device and a flat panel display device, and more particularly, to an organic light emitting device including an organic layer containing a phenylcarbazole-based compound that has excellent hole mobility between a pair of electrodes capable of generating resonance during the operation of the light emitting device, an organic light emitting device including a hole injection layer having a predetermined range of thickness between a pair of electrodes capable of generating resonance during the operation of the light emitting device, and a flat panel display device including the organic light emitting device. The organic light emitting device has low driving voltage, excellent current density, high brightness, excellent color purity, high efficiency, and long lifetime. Particularly, the organic light emitting device has excellent lifetime.

2. Description of the Related Art

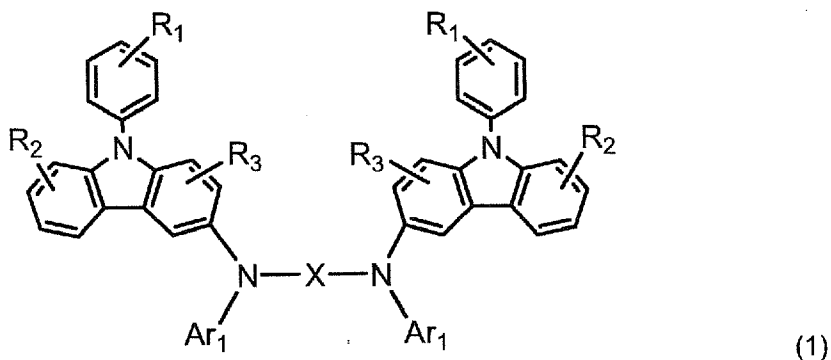
[0003] Organic light emitting devices are self-emission displays that emit light by recombination of electrons and holes in an organic layer made of a fluorescent or phosphorescent compound when a current is applied to the organic layer. Organic light emitting devices are lightweight, have simple constituent elements, an easy fabrication process, superior image quality, and a wide viewing angle. Furthermore, organic light emitting devices can realize dynamic images and high color purity. Organic light emitting devices also have electrical properties such as low power consumption and low driving voltage suitable for portable electronic equipment.

[0004] Organic light emitting devices generally have an organic layer in the form of a multi-layer structure including an electron injection layer, an emission layer, a hole transport layer, etc. instead of including only a single emission layer to improve efficiency and to lower driving voltage. For example, Japanese Patent Laid-Open Publication No. 2002-252089 discloses an organic light emitting device including a hole transport layer.

[0005] However, the driving voltage, current density, brightness, color purity, efficiency and lifetime of a conventional organic light emitting device do not meet desired levels. Accordingly, these properties must be improved.

SUMMARY OF THE INVENTION

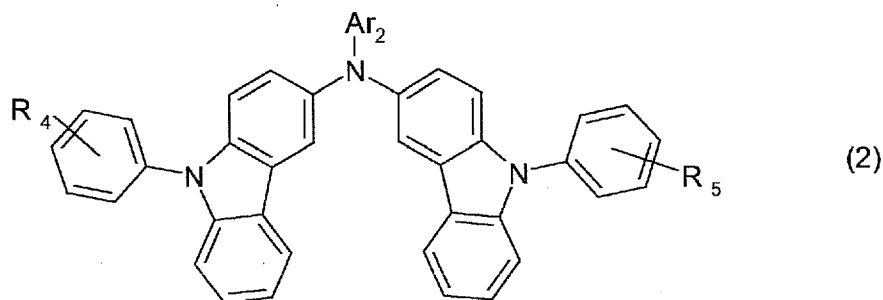
[0006] According to an aspect of the invention there is provided an organic light emitting device comprising a substrate, a first electrode, a second electrode facing the first electrode and an organic layer interposed between the first electrode and the second electrode, wherein resonance is occurring between the first electrode and the second electrode during the operation of the organic light emitting device and the organic layer comprises a compound selected from the group consisting of compounds represented by any of formulae (1) to (3):



where X is selected from the group consisting of a substituted or unsubstituted C₁-C₃₀ alkylene group, a substituted or

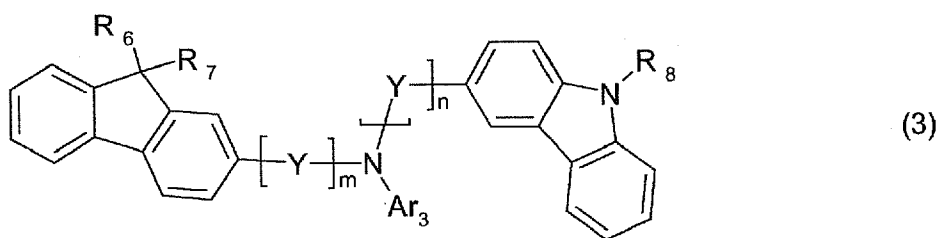
unsubstituted C₂-C₃₀ alkenylene group, a substituted or unsubstituted C₆-C₃₀ arylene group, a substituted or unsubstituted C₂-C₃₀ heteroarylene group, and a substituted or unsubstituted C₂-C₃₀ hetero ring, each R₁, each R₂ and each R₃ is independently selected from the group consisting of a hydrogen atom, a substituted or unsubstituted C₁-C₃₀ alkyl group, a substituted or unsubstituted C₁-C₃₀ alkoxy group, a substituted or unsubstituted C₆-C₃₀ aryl group, a substituted or unsubstituted C₆-C₃₀ aryloxy group, a substituted or unsubstituted C₂-C₃₀ hetero ring, a substituted or unsubstituted C₅-C₃₀ polycyclic condensed ring, a hydroxy group, a cyano group, and a substituted or unsubstituted amino group, wherein two or more of R₁, R₂ and R₃ can be optionally bound with one another to form a saturated or unsaturated carbon ring, and

each Ar₁ is independently selected from the group consisting of substituted or unsubstituted C₆-C₃₀ aryl group and a substituted or unsubstituted C₂-C₃₀ heteroaryl group;



wherein R₄ and R₅ are independently selected from the group consisting of a hydrogen atom, a substituted or unsubstituted C₁-C₃₀ alkyl group, a substituted or unsubstituted C₁-C₃₀ alkoxy group, a substituted or unsubstituted C₆-C₃₀ aryl group, a substituted or unsubstituted C₆-C₃₀ aryloxy group, a substituted or unsubstituted C₂-C₃₀ hetero ring, a substituted or unsubstituted C₅-C₃₀ polycyclic condensed ring, a hydroxy group, a cyano group, and a substituted or unsubstituted amino group, wherein R₄ and R₅ can be optionally bound with one another to form a saturated or unsaturated carbon ring, and

Ar₂ is a substituted or unsubstituted C₆-C₃₀ aryl group or a substituted or unsubstituted C₂-C₃₀ heteroaryl group; and



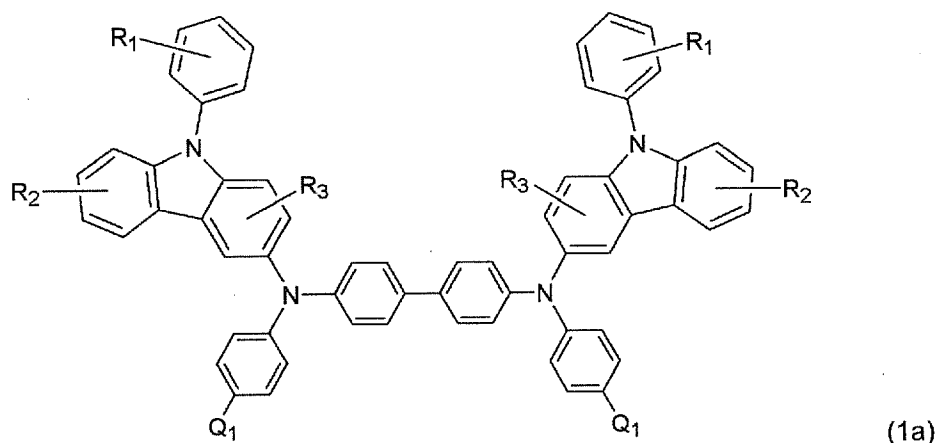
wherein R₆, R₇ and R₈ are independently selected from the group consisting of a hydrogen atom, a substituted or unsubstituted C₁-C₃₀ alkyl group, a substituted or unsubstituted C₁-C₃₀ alkoxy group, a substituted or unsubstituted C₆-C₃₀ aryl group, a substituted or unsubstituted C₆-C₃₀ aryloxy group, a substituted or unsubstituted C₂-C₃₀ hetero ring, a substituted or unsubstituted C₅-C₃₀ polycyclic condensed ring, a hydroxy group, a cyano group, and a substituted or unsubstituted amino group, wherein R₆ and R₇ can be optionally bound with one another to form a saturated or unsaturated carbon ring,

Ar₃ is a substituted or unsubstituted C₆-C₃₀ aryl group or a substituted or unsubstituted C₂-C₃₀ heteroaryl group, each Y is selected independently from the group consisting of a substituted or unsubstituted C₁-C₃₀ alkyl group, a substituted or unsubstituted C₆-C₃₀ aryl group, and a substituted or unsubstituted C₂-C₃₀ hetero ring, and m and n are an integer from 0 to 5.

[0007] According to a preferred embodiment, in the compounds of formula (1) R₁ to R₃ are hydrogen atoms. In the compounds of formula (1) - preferably in combination with the foregoing embodiment - Ar₁ may be a substituted or unsubstituted C₆-C₃₀ aryl group. At last, in the compounds of formula (1) - preferably in combination with any of the two foregoing embodiments - X may be selected from the group consisting of a substituted or unsubstituted C₆-C₃₀ arylene

group and a substituted or unsubstituted C₂-C₃₀ heteroarylene group.

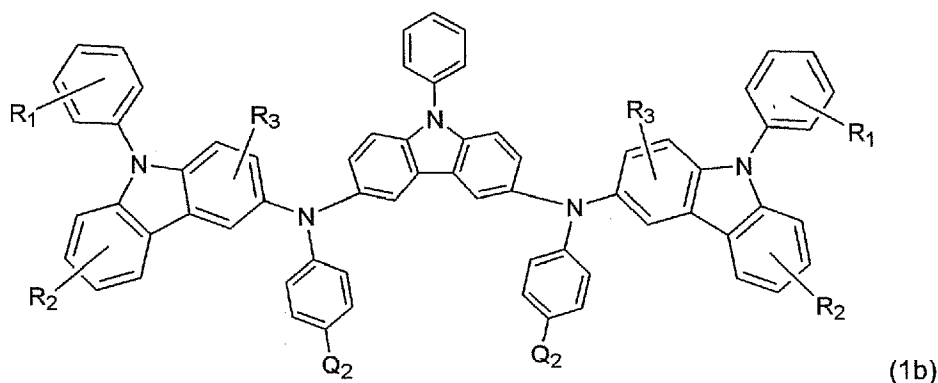
[0008] According to another preferred embodiment, the compounds of formula (1) may be represented by formula (1 a):



where each R₁, each R₂, and each R₃ are each independently selected from the group consisting of a hydrogen atom, a substituted or unsubstituted C₁-C₃₀ alkyl group, a substituted or unsubstituted C₁-C₃₀ alkoxy group, a substituted or unsubstituted C₆-C₃₀ aryl group, a substituted or unsubstituted C₆-C₃₀ aryloxy group, a substituted or unsubstituted C₂-C₃₀ hetero ring, a substituted or unsubstituted C₅-C₃₀ polycyclic condensed ring, a hydroxy group, a cyano group, and a substituted or unsubstituted amino group, wherein two or more of R₁, R₂ and R₃ can be optionally bound with one another to form a saturated or unsaturated carbon ring; and

each Q₁ is independently selected from the group consisting of a hydrogen atom, a cyano group, a fluorine atom, a substituted or unsubstituted C₁-C₃₀ alkyl group, a substituted or unsubstituted C₆-C₃₀ aryl group, a substituted or unsubstituted C₂-C₃₀ hetero ring, and a substituted or unsubstituted amino group. Preferably, R₁ to R₃ are hydrogen atoms.

[0009] According to another preferred embodiment, the compounds of formula (1) may also be represented by formula (1 b):

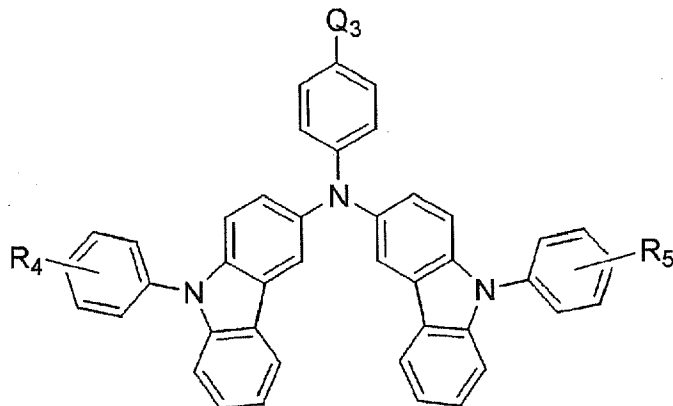


where each R₁, each R₂, and each R₃ are each independently selected from the group consisting of a hydrogen atom, a substituted or unsubstituted C₁-C₃₀ alkyl group, a substituted or unsubstituted C₁-C₃₀ alkoxy group, a substituted or unsubstituted C₆-C₃₀ aryl group, a substituted or unsubstituted C₆-C₃₀ aryloxy group, a substituted or unsubstituted C₂-C₃₀ hetero ring, a substituted or unsubstituted C₅-C₃₀ polycyclic condensed ring, a hydroxy group, a cyano group, and a substituted or unsubstituted amino group, wherein two or more of R₁, R₂ and R₃ can be optionally bound with one another to form a saturated or unsaturated carbon ring; and

each Q₂ is independently selected from the group consisting of a hydrogen atom, a cyano group, a fluorine atom, a substituted or unsubstituted C₁-C₃₀ alkyl group, a substituted or unsubstituted C₆-C₃₀ aryl group, a substituted or unsubstituted C₂-C₃₀ hetero ring, and a substituted or unsubstituted amino group. Preferably, R₁ to R₃ are hydrogen atoms.

[0010] According to a preferred embodiment, in the compounds of formula (2) R_4 and R_5 are hydrogen atoms. In the compounds of formula (2) - preferably in combination with the foregoing embodiment - Ar_2 is a substituted or unsubstituted C_6 - C_{30} aryl group.

[0011] According to another preferred embodiment, the compounds of formula (2) may be represented by formula (2a):

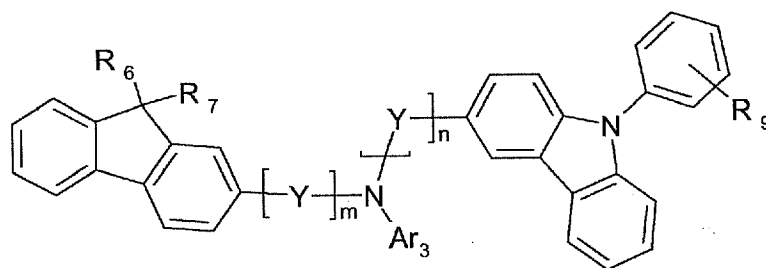


(2a)

where R_4 and R_5 are each independently selected from the group consisting of a hydrogen atom, a substituted or unsubstituted C_1 - C_{30} alkyl group, a substituted or unsubstituted C_1 - C_{30} alkoxy group, a substituted or unsubstituted C_6 - C_{30} aryl group, a substituted or unsubstituted C_6 - C_{30} aryloxy group, a substituted or unsubstituted C_2 - C_{30} hetero ring, a substituted or unsubstituted C_5 - C_{30} polycyclic condensed ring, a hydroxy group, a cyano group, and a substituted or unsubstituted amino group, wherein R_4 and R_5 can be optionally bound with one another to form a saturated or unsaturated carbon ring; and

Q_3 is selected from the group consisting of a hydrogen atom, a cyano group, a fluorine atom, a substituted or unsubstituted C_1 - C_{30} alkyl group, a substituted or unsubstituted C_6 - C_{30} aryl group, a substituted or unsubstituted C_2 - C_{30} hetero ring, and a substituted or unsubstituted amino group. Preferably, R_4 and R_5 are hydrogen atoms.

[0012] According to another preferred embodiment, the compounds of formula (3) may be represented by formula (3c):

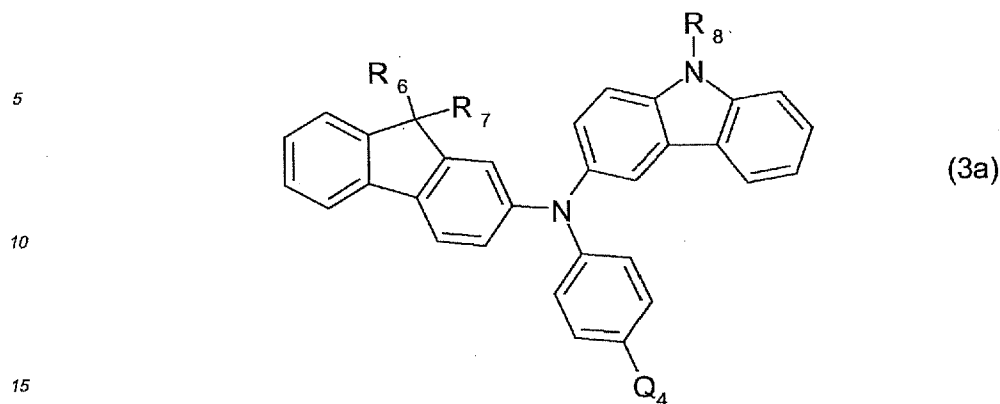


(3c)

where R_9 is selected from the group consisting of a hydrogen atom, a substituted or unsubstituted C_1 - C_{30} alkyl group, a substituted or unsubstituted C_1 - C_{30} alkoxy group, a substituted or unsubstituted C_6 - C_{30} aryl group, a substituted or unsubstituted C_6 - C_{30} aryloxy group, a substituted or unsubstituted C_2 - C_{30} hetero ring, a substituted or unsubstituted C_5 - C_{30} polycyclic condensed ring, a hydroxy group, a cyano group, and a substituted or unsubstituted amino group.

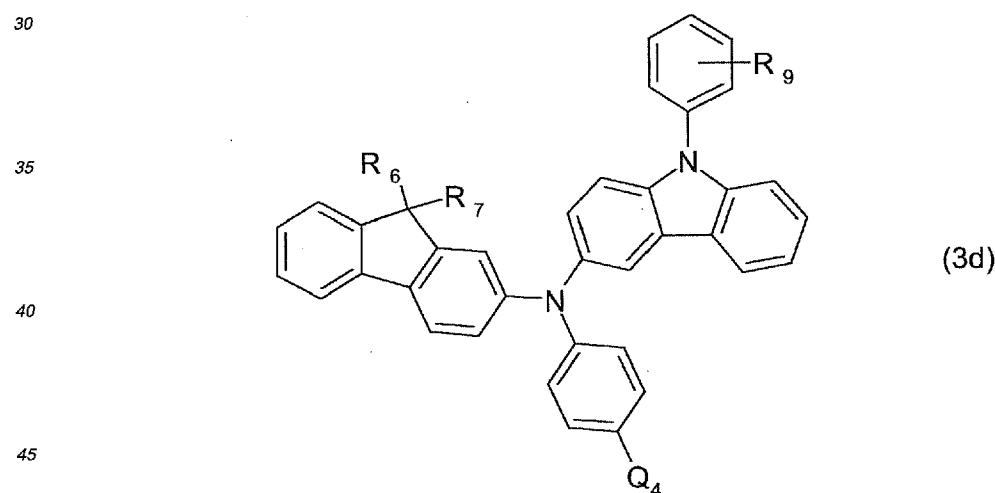
[0013] According to a preferred embodiment, in the compounds of formula (3) or formula (3c) R_8 or R_9 is a hydrogen atom. In the compounds of formula (3) or formula (3c) - preferably in combination with the foregoing embodiment - Ar_3 may be a substituted or unsubstituted C_6 - C_{30} aryl group. In the compounds of formula (3) or formula (3c) - preferably in combination with any of the two foregoing embodiments - R_6 and R_7 may each be a methyl group or a phenyl group. At last, in the compounds of formula (3) or formula (3c) - preferably in combination with any of the three foregoing embodiments - m is 1, n is zero and Y is a phenyl group connected to the N atom and the fluorene moiety in positions 1 and 4.

[0014] According to another preferred embodiment, the compounds of formula (3) may be represented by formula (3a):



where R_6 , R_7 and R_8 are each independently selected from the group consisting of a hydrogen atom, a substituted or unsubstituted C_1 - C_{30} alkyl group, a substituted or unsubstituted C_1 - C_{30} alkoxy group, a substituted or unsubstituted C_6 - C_{30} aryl group, a substituted or unsubstituted C_6 - C_{30} aryloxy group, a substituted or unsubstituted C_2 - C_{30} hetero ring, a substituted or unsubstituted C_5 - C_{30} polycyclic condensed ring, a hydroxy group, a cyano group, and a substituted or unsubstituted amino group, wherein two or more of R_6 , R_7 and R_8 can be optionally bound with one another to form a saturated or unsaturated carbon ring; and Q_4 is selected from the group consisting of a hydrogen atom, a cyano group, a fluorine atom, a substituted or unsubstituted C_1 - C_{30} alkyl group, a substituted or unsubstituted C_6 - C_{30} aryl group, a substituted or unsubstituted C_2 - C_{30} hetero ring, and a substituted or unsubstituted amino group.

[0015] According to another preferred embodiment, the compounds of formula (3) may be represented by formula (3d):



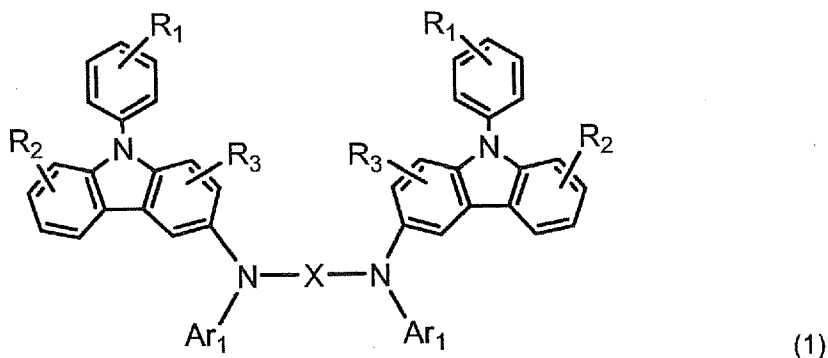
where R_6 , R_7 and R_9 are each independently selected from the group consisting of a hydrogen atom, a substituted or unsubstituted C_1 - C_{30} alkyl group, a substituted or unsubstituted C_1 - C_{30} alkoxy group, a substituted or unsubstituted C_6 - C_{30} aryl group, a substituted or unsubstituted C_6 - C_{30} aryloxy group, a substituted or unsubstituted C_2 - C_{30} hetero ring, a substituted or unsubstituted C_5 - C_{30} polycyclic condensed ring, a hydroxy group, a cyano group, and a substituted or unsubstituted amino group, wherein two or more of R_6 , R_7 and R_8 can be optionally bound with one another to form a saturated or unsaturated carbon ring; and Q_4 is selected from the group consisting of a hydrogen atom, a cyano group, a fluorine atom, a substituted or unsubstituted C_1 - C_{30} alkyl group, a substituted or unsubstituted C_6 - C_{30} aryl group, a substituted or unsubstituted C_2 - C_{30} hetero ring, and a substituted or unsubstituted amino group. Preferably, R_9 is a hydrogen atom and/or R_6 and R_7 may each be a methyl group or a phenyl group.

[0016] Preferably, one of the first electrode and the second electrode is being a reflective electrode and the other is being a semitransparent or transparent electrode. The first electrode may be formed on the substrate and may be the reflective electrode; the second electrode may be the semitransparent or transparent electrode. in the organic light emitting device of one of the foregoing embodiments, the organic layer comprising said at least one compound selected from the group of compounds represented by formulae (1) to (3) may be one of a hole injection layer, a hole transport layer, and a single layer having hole injecting and transporting properties. Preferably, the organic layer comprising said at least one compound selected from the group of compounds represented by formulae (1) to (3) is a hole injection layer.

[0017] Where the organic light emitting device further comprises an emission layer having a red emission region, the thickness of a region of the hole injection layer formed under the red emission region is preferably in the range of 1,600 to 2,200 Å. Where the organic light emitting device further comprises an emission layer having a green emission region, the thickness of a region of the hole injection layer formed under the green emission region is preferably in the range of 1,400 to 1,800 Å. Where the organic light emitting device further comprises an emission layer having a blue emission region, the thickness of a region of the hole injection layer formed under the blue emission region is preferably in the range of 1,000 to 1,400 Å. Where the organic light emitting device further comprises an emission layer having a red emission region, a blue emission region and a red emission region, the hole injection layer comprises a first region formed under the red emission region, a second region formed under the green emission region and a third region formed under the blue emission region. Preferably, the thickness of the first region is in the range of 1,600 to 2,200 Å, the thickness of the second region is in the range of 1,400 to 1,800 Å, and the thickness of the third region is in the range of 1,000 to 1,400 Å.

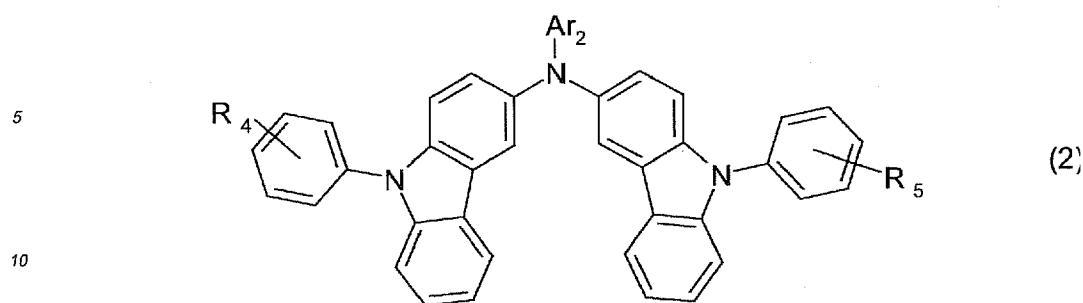
[0018] The organic light emitting device may further comprise a hole transport layer. Where the organic light emitting device further comprises an emission layer having a red emission region, the total thickness of a region of the hole transport layer and the hole injection layer formed under the red emission region is preferably in the range of 2,000 to 2,400 Å, especially in the range of 1,600 to 2,200 Å. Where the organic light emitting device further comprises an emission layer having a green emission region, the total thickness of a region of the hole transport layer and the hole injection layer formed under the green emission region is preferably in the range of 1,600 to 2,000 Å, especially in the range of 1,400 to 1,800 Å. Where the organic light emitting device further comprises an emission layer having a blue emission region, the total thickness of a region of the hole transport layer and the hole injection layer formed under the blue emission region is preferably in the range of 1,200 to 1,600 Å, especially in the range of 1,000 to 1,400 Å.

[0019] It is also provided a method for manufacturing a compound selected from the group consisting of compounds represented by any of formulae (1) to (3):



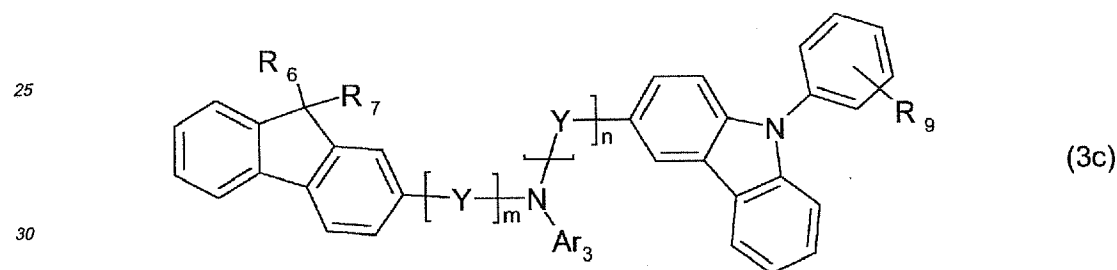
where X is selected from the group consisting of a substituted or unsubstituted C₁-C₃₀ alkylene group, a substituted or unsubstituted C₂-C₃₀ alkenylene group, a substituted or unsubstituted C₆-C₃₀ arylene group, a substituted or unsubstituted C₂-C₃₀ heteroarylene group, and a substituted or unsubstituted C₂-C₃₀ hetero ring, each R₁, each R₂ and each R₃ is independently selected from the group consisting of a hydrogen atom, a substituted or unsubstituted C₁-C₃₀ alkyl group, a substituted or unsubstituted C₁-C₃₀ alkoxy group, a substituted or unsubstituted C₆-C₃₀ aryl group, a substituted or unsubstituted C₆-C₃₀ aryloxy group, a substituted or unsubstituted C₂-C₃₀ hetero ring, a substituted or unsubstituted C₅-C₃₀ polycyclic condensed ring, a hydroxy group, a cyano group, and a substituted or unsubstituted amino group, wherein two or more of R₁, R₂ and R₃ can be optionally bound with one another to form a saturated or unsaturated carbon ring, and

Ar₁ is independently selected from the group consisting of substituted or unsubstituted C₆-C₃₀ aryl group and a substituted or unsubstituted C₂-C₃₀ heteroaryl group;



15 wherein R_4 and R_5 are independently selected from the group consisting of a hydrogen atom, a substituted or unsubstituted C_1 - C_{30} alkyl group, a substituted or unsubstituted C_1 - C_{30} alkoxy group, a substituted or unsubstituted C_6 - C_{30} aryl group, a substituted or unsubstituted C_6 - C_{30} aryloxy group, a substituted or unsubstituted C_2 - C_{30} hetero ring, a substituted or unsubstituted C_5 - C_{30} polycyclic condensed ring, a hydroxy group, a cyano group, and a substituted or unsubstituted amino group, wherein R_4 and R_5 can be optionally bound with one another to form a saturated or unsaturated carbon ring, and

20 Ar_2 is a substituted or unsubstituted C_6 - C_{30} aryl group or a substituted or unsubstituted C_2 - C_{30} heteroaryl group; and



35 wherein R_6 , R_7 and R_9 are independently selected from the group consisting of a hydrogen atom, a substituted or unsubstituted C_1 - C_{30} alkyl group, a substituted or unsubstituted C_1 - C_{30} alkoxy group, a substituted or unsubstituted C_6 - C_{30} aryl group, a substituted or unsubstituted C_6 - C_{30} aryloxy group, a substituted or unsubstituted C_2 - C_{30} hetero ring, a substituted or unsubstituted C_5 - C_{30} polycyclic condensed ring, a hydroxy group, a cyano group, and a substituted or unsubstituted amino group, wherein R_6 and R_7 can be optionally bound with one another to form a saturated or unsaturated carbon ring,

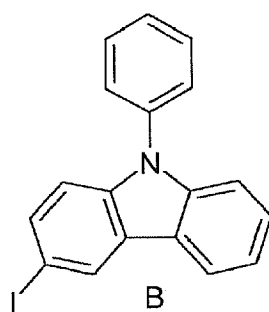
40 Ar_3 is a substituted or unsubstituted C_6 - C_{30} aryl group or a substituted or unsubstituted C_2 - C_{30} heteroaryl group, each Y is selected independently from the group consisting of a substituted or unsubstituted C_1 - C_{30} alkyl group, a substituted or unsubstituted C_6 - C_{30} aryl group, and a substituted or unsubstituted C_2 - C_{30} hetero ring, and m and n are an integer from 0 to 5,

45 the method including the step of:

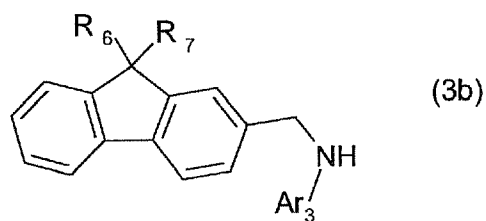
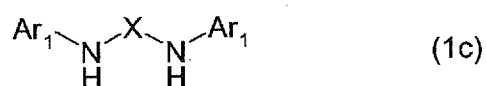
coupling a compound of formula B

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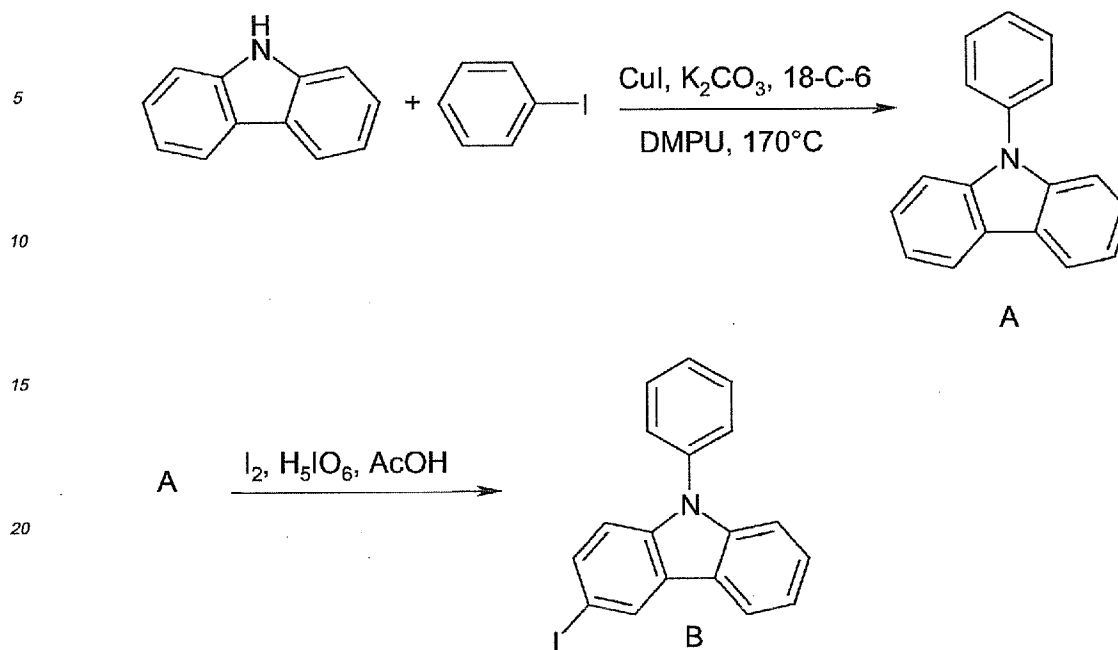
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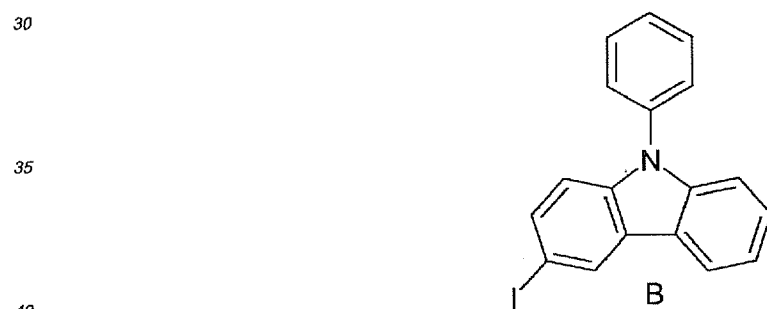
via a palladium catalyzed coupling reaction with a primary or secondary amine according to any one of formulae (1c), (2b) and (3b)



[0020] Preferably, the compound of formula B is synthesized according to the following reaction scheme:



[0021] It is also provided an intermediate product according to compound of formula B:



[0022] The present invention provides an improved organic light emitting device. The organic light emitting device includes an organic layer containing a compound that has excellent hole mobility between a pair of electrodes capable of generating resonance during the operation of the light emitting device. The organic light emitting device may include a hole injection layer having a predetermined range of thickness between a pair of electrodes capable of generating resonance during the operation of the light emitting device. The invention provides also a flat panel display device including the above mentioned organic light emitting device.

[0023] According to another aspect of the present invention, there is provided an organic light emitting device including: a substrate; a first electrode; a second electrode; and an organic layer interposed between the first electrode and the second electrode and including an emission layer having a red emission region and a hole injection layer having a region formed under the red emission region, wherein one of the first electrode and the second electrode is a reflective electrode and the other is a semitransparent or transparent electrode, and wherein the thickness of the region of the hole injection layer formed under the red emission region is in the range of 1,600 to 2,200 Å.

[0024] According to another aspect of the present invention, there is provided an organic light emitting device including: a substrate; a first electrode; a second electrode; and an organic layer interposed between the first electrode and the second electrode and including an emission layer having a green emission region and a hole injection layer having a region formed under the green emission region, wherein one of the first electrode and the second electrode is a reflective

electrode and the other is a semitransparent or transparent electrode, and wherein the thickness of the region of the hole injection layer formed under the green emission region is in the range of 1,400 to 1,800 Å.

[0025] According to another aspect of the present invention, there is provided an organic light emitting device including: a substrate; a first electrode; a second electrode; and an organic layer interposed between the first electrode and the second electrode and including an emission layer having a blue emission region and a hole injection layer having a region formed under the blue emission region, wherein one of the first electrode and the second electrode is a reflective electrode and the other is a semitransparent or transparent electrode, and wherein the thickness of the region of the hole injection layer formed under the blue emission region is in the range of 1,000 to 1,400 Å.

[0026] The organic light emitting device according to the invention may be used in a flat panel display device, wherein the first electrode of the organic light emitting device is electrically connected to a source electrode or a drain electrode of a thin film transistor.

[0027] The organic light emitting device has low driving voltage, excellent current density, high brightness, excellent color purity, high efficiency, and long lifetime. Particularly, the organic light emitting device has excellent lifetime.

BRIEF DESCRIPTION OF THE DRAWINGS

[0028] A more complete appreciation of the present invention, and many of the above and other features and advantages of the present invention, will be readily apparent as the same becomes better understood by reference to the following detailed description when considered in conjunction with the accompanying drawings in which like reference symbols indicate the same or similar components, wherein:

FIG. 1 schematically illustrates a structure of an organic light emitting device according to an embodiment of the present invention;

FIG. 2 schematically illustrates an organic light emitting device including an emission layer comprised of a red emission region, a green emission region, and blue emission region according to an embodiment of the present invention; and

FIGS. 3 through 7 are graphs illustrating current efficiencies, luminance, and driving voltages of an organic light emitting device according to an embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

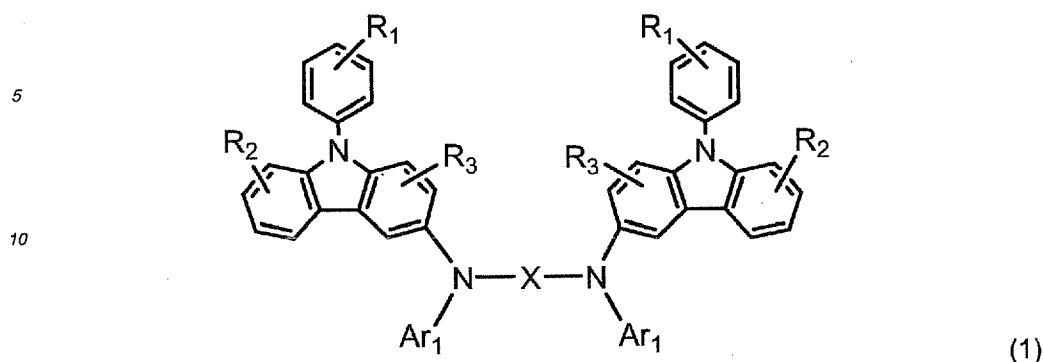
[0029] Hereinafter, the present invention will now be described more fully with reference to the accompanying drawings, in which exemplary embodiments of the invention are shown. The invention may, however, be embodied in many different forms and should not be construed as being limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the concept of the invention to those skilled in the art.

[0030] An organic light emitting device according to an embodiment of the present invention includes a substrate, a first electrode, a second electrode and an organic layer. The organic layer is disposed between the first electrode and the second electrode and includes an emission layer. The organic layer can emit red, green, and/or blue light according to a material used to form the emission layer.

[0031] One of the first electrode and the second electrode is a reflective electrode and the other is a semitransparent or transparent electrode. Accordingly, resonance may occur between the first electrode and the second electrode during the operation of the light emitting device. Thus, the light generated in the organic layer between the first electrode and the second electrode resonates between the first electrode and the second electrode during the operation of the light emitting device, and the light is extracted from the organic light emitting device. Thus, luminance of the light and light emitting efficiency can be enhanced.

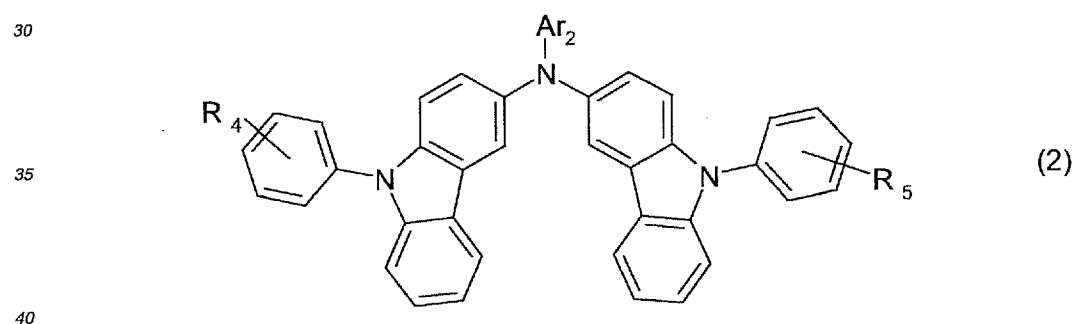
[0032] The first electrode may be formed on the substrate. For example, the first electrode may be a reflective electrode, and the second electrode may be a semitransparent or transparent electrode. Accordingly, the light generated in the organic layer between the first electrode and the second electrode resonates between the first electrode and the second electrode during the operation of the light emitting device, and the light is extracted through the second electrode, that is, in a direction away from the substrate.

[0033] The organic layer of the organic light emitting device according to the current embodiment of the present invention includes a phenylcarbazole-based compound. In particular, the organic layer may include a layer including at least one of the compounds represented by formulae (1) to (3) below.



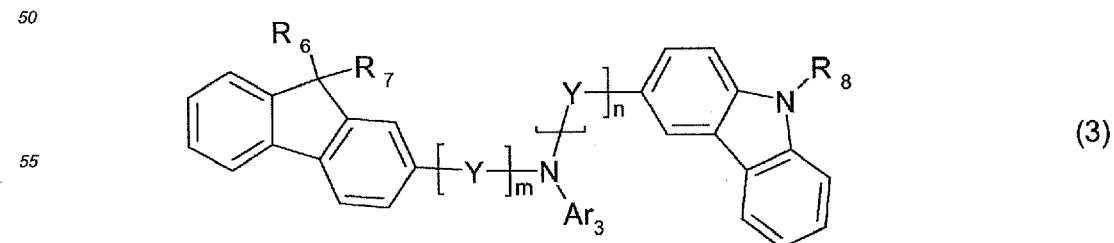
where X is selected from the group consisting of a substituted or unsubstituted C₁-C₃₀ alkylene group, a substituted or unsubstituted C₂-C₃₀ alkenylene group, a substituted or unsubstituted C₆-C₃₀ arylene group, a substituted or unsubstituted C₂-C₃₀ heteroarylene group, and a substituted or unsubstituted C₂-C₃₀ hetero ring, each R₁, each R₂ and each R₃ is independently selected from the group consisting of a hydrogen atom, a substituted or unsubstituted C₁-C₃₀ alkyl group, a substituted or unsubstituted C₁-C₃₀ alkoxy group, a substituted or unsubstituted C₆-C₃₀ aryl group, a substituted or unsubstituted C₆-C₃₀ aryloxy group, a substituted or unsubstituted C₂-C₃₀ hetero ring, a substituted or unsubstituted C₅-C₃₀ polycyclic condensed ring, a hydroxy group, a cyano group, and a substituted or unsubstituted amino group, wherein two or more of R₁, R₂ and R₃ can be optionally bound with one another to form a saturated or unsaturated carbon ring, and

each Ar₁ is independently selected from the group consisting of substituted or unsubstituted C₆-C₃₀ aryl group and a substituted or unsubstituted C₂-C₃₀ heteroaryl group;



wherein R₄ and R₅ are independently selected from the group consisting of a hydrogen atom, a substituted or unsubstituted C₁-C₃₀ alkyl group, a substituted or unsubstituted C₁-C₃₀ alkoxy group, a substituted or unsubstituted C₆-C₃₀ aryl group, a substituted or unsubstituted C₆-C₃₀ aryloxy group, a substituted or unsubstituted C₂-C₃₀ hetero ring, a substituted or unsubstituted C₅-C₃₀ polycyclic condensed ring, a hydroxy group, a cyano group, and a substituted or unsubstituted amino group, wherein R₄ and R₅ can be optionally bound with one another to form a saturated or unsaturated carbon ring, and

Ar₂ is a substituted or unsubstituted C₆-C₃₀ aryl group or a substituted or unsubstituted C₂-C₃₀ heteroaryl group; and



wherein R_6 , R_7 and R_8 are independently selected from the group consisting of a hydrogen atom, a substituted or unsubstituted C_1 - C_{30} alkyl group, a substituted or unsubstituted C_1 - C_{30} alkoxy group, a substituted or unsubstituted C_6 - C_{30} aryl group, a substituted or unsubstituted C_6 - C_{30} aryloxy group, a substituted or unsubstituted C_2 - C_{30} hetero ring, a substituted or unsubstituted C_5 - C_{30} polycyclic condensed ring, a hydroxy group, a cyano group, and a substituted or unsubstituted amino group, wherein R_6 and R_7 can be optionally bound with one another to form a saturated or unsaturated carbon ring,

Ar_3 is a substituted or unsubstituted C_6 - C_{30} aryl group or a substituted or unsubstituted C_2 - C_{30} heteroaryl group, each Y is selected independently from the group consisting of a substituted or unsubstituted C_1 - C_{30} alkyl group, a substituted or unsubstituted C_6 - C_{30} aryl group, and a substituted or unsubstituted C_2 - C_{30} hetero ring, and

m and n are an integer from 0 to 5.

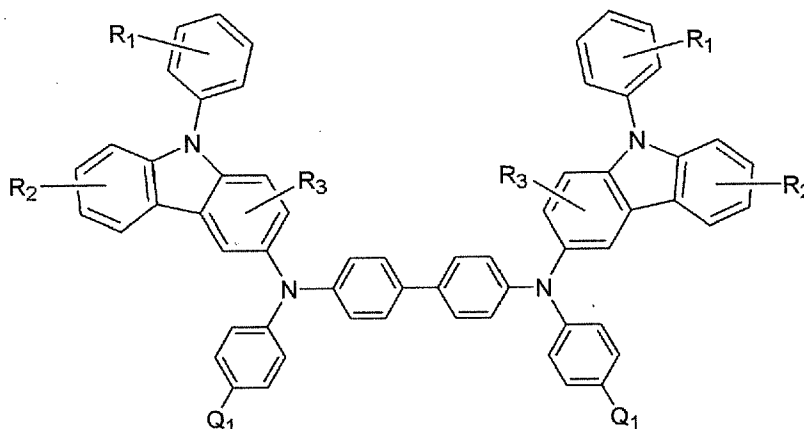
The compounds represented by formula (1), (2), and (3) have a stiff carbazole group, and thus the glass transition temperature or the melting point of the compounds increases. During the operation of the organic light emitting device according to the current embodiment of the present invention, the compounds are highly resistant to heat generated in the organic layer, between the organic layers, or between the organic layer and the electrode according to Joule's Law, and are stable in a high temperature environment. Thus, when the compounds are used to form the organic layer of the organic light emitting device of the present embodiment, long lifetime and excellent luminance can be obtained.

[0034] In particular, the compounds represented by formulae (1) and (2) which have two or more carbazole groups may provide long lifetime and excellent brightness.

[0035] In addition, the organic light emitting device of the present embodiment including an organic layer containing a compound represented by formula (1), (2) or (3) has excellent stability during storage and operation. This feature can be explained by, for example, but not limited to, a high T_g (glass transition temperature) of the compound represented by formula (1), (2) or (3).

[0036] The compound represented by formula (1) may include a compound represented by formula (1a) below, but is not limited thereto.

Formula (1a)

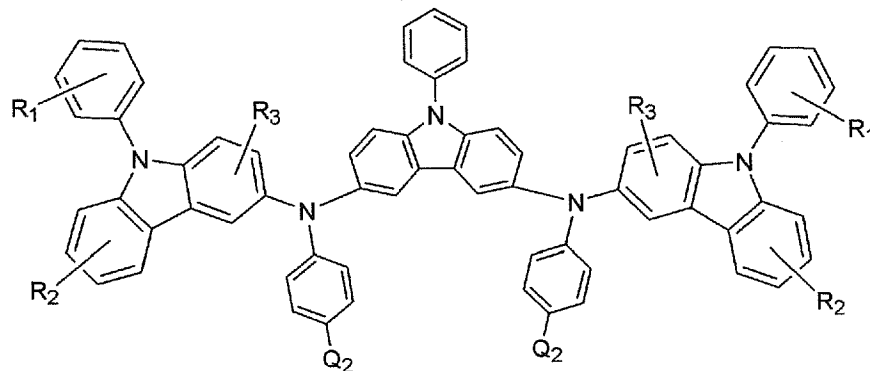


[0037] Here, each R_1 , each R_2 , and each R_3 are each independently one of a hydrogen atom, a substituted or unsubstituted C_1 - C_{30} alkyl group, a substituted or unsubstituted C_1 - C_{30} alkoxy group, a substituted or unsubstituted C_6 - C_{30} aryl group, a substituted or unsubstituted C_6 - C_{30} aryloxy group, a substituted or unsubstituted C_2 - C_{30} hetero ring, a substituted or unsubstituted C_5 - C_{30} polycyclic condensed ring, a hydroxy group, a cyano group, and a substituted or unsubstituted amino group, wherein two or more of R_1 , R_2 and R_3 can be optionally bound with one another to form a saturated or unsaturated carbon ring; and

each Q_1 is independently one of a hydrogen atom, a cyano group, a fluorine atom, a substituted or unsubstituted C_1 - C_{30} alkyl group, a substituted or unsubstituted C_6 - C_{30} aryl group, a substituted or unsubstituted C_2 - C_{30} hetero ring, and a substituted or unsubstituted amino group.

[0038] The compound represented by formula (1) may include a compound represented by formula (1 b) below, but is not limited thereto.

Formula (1b)

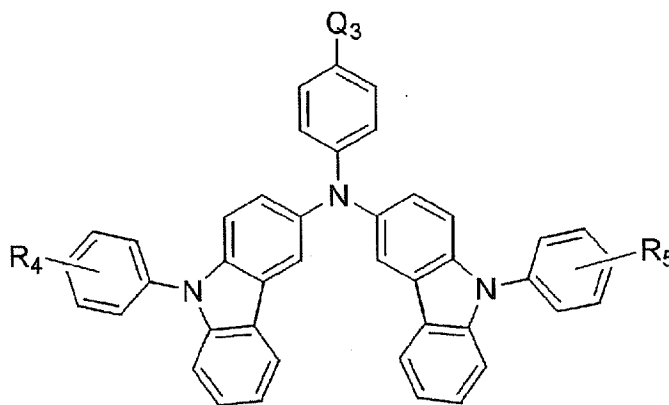


[0039] Here, each R₁, each R₂, and each R₃ are each independently one of a hydrogen atom, a substituted or unsubstituted C₁-C₃₀ alkyl group, a substituted or unsubstituted C₁-C₃₀ alkoxy group, a substituted or unsubstituted C₆-C₃₀ aryl group, a substituted or unsubstituted C₆-C₃₀ aryloxy group, a substituted or unsubstituted C₂-C₃₀ hetero ring, a substituted or unsubstituted C₅-C₃₀ polycyclic condensed ring, a hydroxy group, a cyano group, and a substituted or unsubstituted amino group, wherein two or more of R₁, R₂ and R₃ can be optionally bound with one another to form a saturated or unsaturated carbon ring; and

each Q₂ is one selected from the group consisting of a hydrogen atom, a cyano group, a fluorine atom, a substituted or unsubstituted C₁-C₃₀ alkyl group, a substituted or unsubstituted C₆-C₃₀ aryl group, a substituted or unsubstituted C₂-C₃₀ hetero ring, and a substituted or unsubstituted amino group.

[0040] The compound represented by formula (2) may include a compound represented by formula (2a) below, but is not limited thereto.

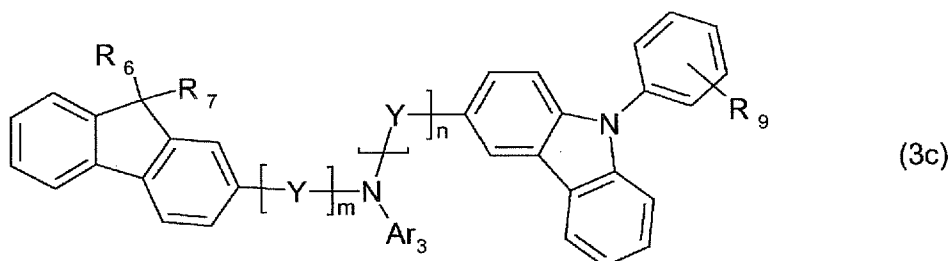
Formula (2a)



[0041] Here, R₄ and R₅ are each independently one of a hydrogen atom, a substituted or unsubstituted C₁-C₃₀ alkyl group, a substituted or unsubstituted C₁-C₃₀ alkoxy group, a substituted or unsubstituted C₆-C₃₀ aryl group, a substituted or unsubstituted C₆-C₃₀ aryloxy group, a substituted or unsubstituted C₂-C₃₀ hetero ring, a substituted or unsubstituted C₅-C₃₀ polycyclic condensed ring, a hydroxy group, a cyano group, and a substituted or unsubstituted amino group,

wherein R_4 and R_5 can be optionally bound with one another to form a saturated or unsaturated carbon ring; and Q_3 is one of a hydrogen atom, a cyano group, a fluorine atom, a substituted or unsubstituted C_1 - C_{30} alkyl group, a substituted or unsubstituted C_6 - C_{30} aryl group, a substituted or unsubstituted C_2 - C_{30} hetero ring, and a substituted or unsubstituted amino group.

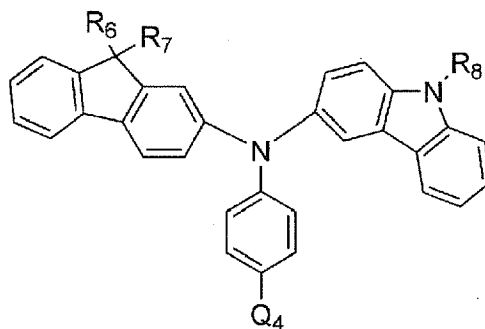
[0042] The compounds of formula (3) may be represented by formula (3c):



where R_9 is selected from the group consisting of a hydrogen atom, a substituted or unsubstituted C_1 - C_{30} alkyl group, a substituted or unsubstituted C_1 - C_{30} alkoxy group, a substituted or unsubstituted C_6 - C_{30} aryl group, a substituted or unsubstituted C_6 - C_{30} aryloxy group, a substituted or unsubstituted C_2 - C_{30} hetero ring, a substituted or unsubstituted C_5 - C_{30} polycyclic condensed ring, a hydroxy group, a cyano group, and a substituted or unsubstituted amino group.

[0043] The compound represented by formula (3) may include a compound represented by formula (3a) or formula (3d) below, but is not limited thereto.

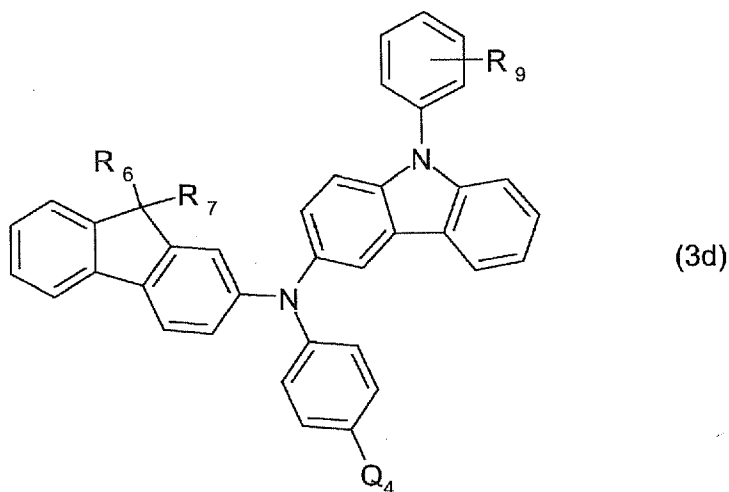
Formula (3a)



[0044] Here, R_6 , R_7 and R_8 are each independently one of a hydrogen atom, a substituted or unsubstituted C_1 - C_{30} alkyl group, a substituted or unsubstituted C_1 - C_{30} alkoxy group, a substituted or unsubstituted C_6 - C_{30} aryl group, a substituted or unsubstituted C_6 - C_{30} aryloxy group, a substituted or unsubstituted C_2 - C_{30} hetero ring, a substituted or unsubstituted C_5 - C_{30} polycyclic condensed ring, a hydroxy group, a cyano group, and a substituted or unsubstituted amino group, wherein two or more of R_6 , R_7 and R_8 can be optionally bound with one another to form a saturated or unsaturated carbon ring; and

Q_4 is one of a hydrogen atom, a cyano group, a fluorine atom, a substituted or unsubstituted C_1 - C_{30} alkyl group, a substituted or unsubstituted C_6 - C_{30} aryl group, a substituted or unsubstituted C_2 - C_{30} hetero ring, and a substituted or unsubstituted amino group.

Formula (3d)



where R_6 , R_7 and R_9 are each independently selected from the group consisting of a hydrogen atom, a substituted or unsubstituted C_1 - C_{30} alkyl group, a substituted or unsubstituted C_1 - C_{30} alkoxy group, a substituted or unsubstituted C_6 - C_{30} aryl group, a substituted or unsubstituted C_6 - C_{30} aryloxy group, a substituted or unsubstituted C_2 - C_{30} hetero ring, a substituted or unsubstituted C_5 - C_{30} polycyclic condensed ring, a hydroxy group, a cyano group, and a substituted or unsubstituted amino group, wherein two or more of R_6 , R_7 and R_8 can be optionally bound with one another to form a saturated or unsaturated carbon ring; and

Q_4 is selected from the group consisting of a hydrogen atom, a cyano group, a fluorine atom, a substituted or unsubstituted C_1 - C_{30} alkyl group, a substituted or unsubstituted C_6 - C_{30} aryl group, a substituted or unsubstituted C_2 - C_{30} hetero ring, and a substituted or unsubstituted amino group. Preferably, R_9 is a hydrogen atom and/or R_6 and R_7 may each be a methyl group or a phenyl group.

[0045] Hereinafter, examples of the groups used to form the compounds represented by the above formulae will now be described in more detail.

[0046] Examples of the unsubstituted C_1 - C_{30} alkyl group may include a methyl group, an ethyl group, a propyl group, an isobutyl group, a sec-butyl group, a pentyl group, an iso-amyl group, and a hexyl group. At least one hydrogen atom in the unsubstituted C_1 - C_{30} alkyl group may be substituted with a halogen atom, a C_1 - C_{30} alkyl group, a C_1 - C_{30} alkoxy group, a low alkylamino group, a hydroxy group, a nitro group, a cyano group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxyl group, a sulfonic acid group, and a phosphoric acid group.

[0047] Examples of the unsubstituted C_1 - C_{30} alkoxy group may include a methoxy group, an ethoxy group, a propoxy group, an isobutyloxy group, a sec-butyloxy group, a pentyloxy group, an iso-amxyloxy group, and a hexyloxy group. At least one hydrogen atom in the unsubstituted C_1 - C_{30} alkoxy group may be substituted with the groups described above with reference to the C_1 - C_{30} alkyl group.

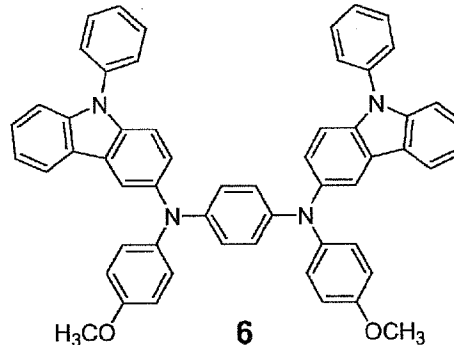
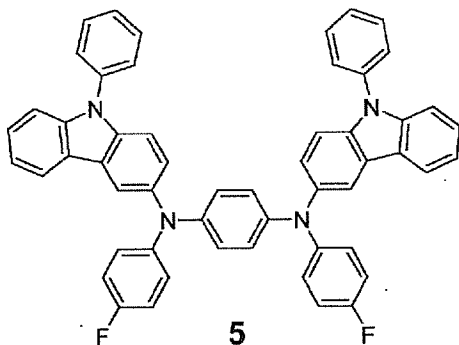
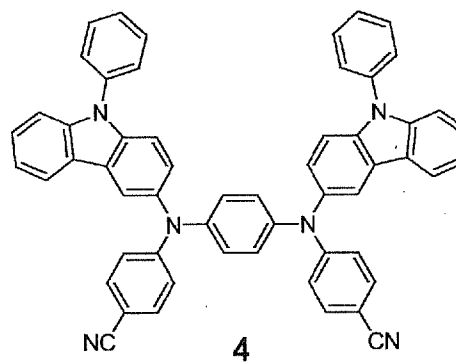
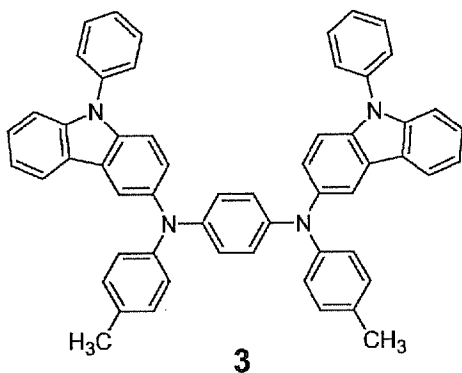
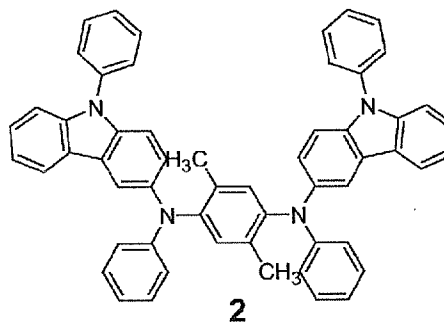
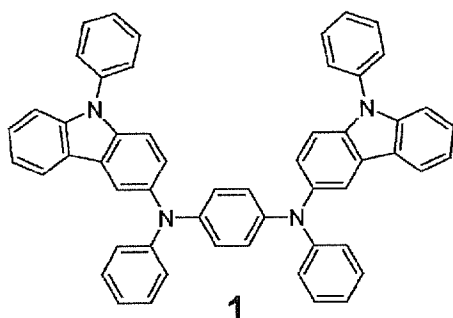
[0048] The C_6 - C_{30} aryl group indicates a carbocyclic aromatic system containing one or more rings, wherein such rings may be bonded together in a pendent manner or may be fused. The term "aryl group" may include an aromatic system such as a phenyl group, a naphthyl group, and a tetrahydronaphthyl group. At least one hydrogen atom in the C_6 - C_{30} aryl group may be substituted with the groups described above with reference to the C_1 - C_{30} alkyl group.

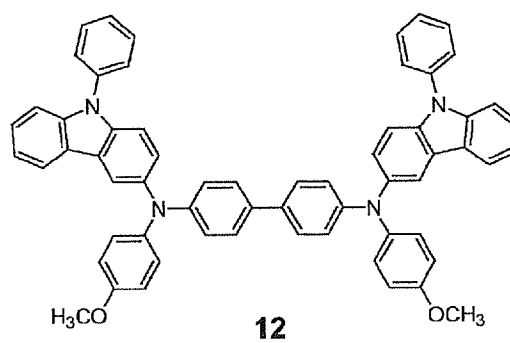
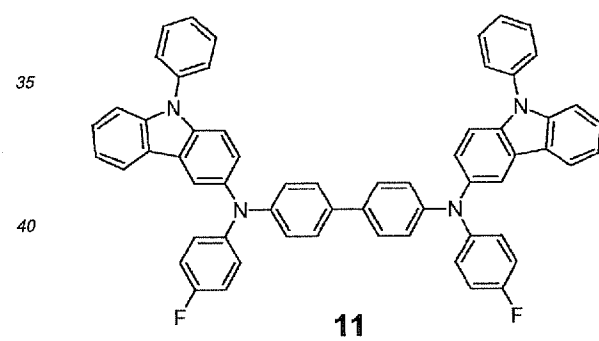
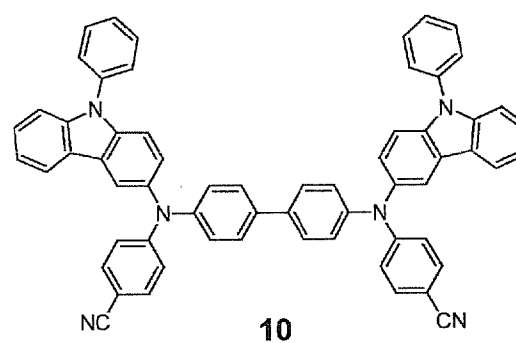
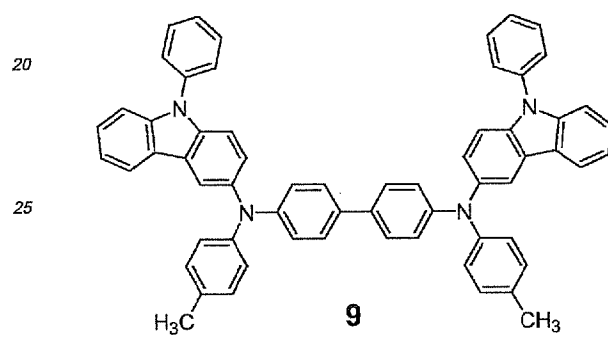
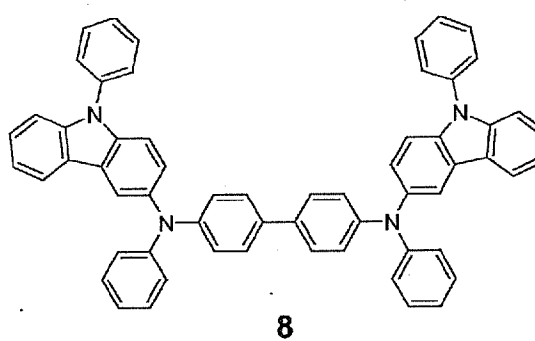
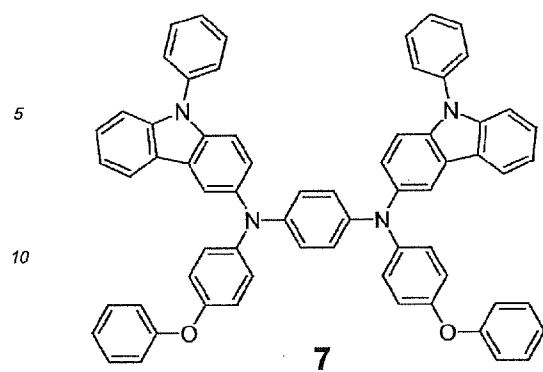
[0049] The C_2 - C_{30} heteroaryl group indicates a monovalent monocyclic ring compound having 2 to 30 membered rings including C and 1 to 3 hetero atoms selected from the group consisting of N, O, P, and S, wherein such rings may be bonded together in a pendent manner or may be fused. Examples of the C_2 - C_{30} heteroaryl group may include a pyridyl group, a thienyl group, and a furyl group. At least one hydrogen atom in the C_2 - C_{30} heteroaryl group may be substituted with the groups described above with reference to the C_1 - C_{30} alkyl group.

[0050] Ar_1 , Ar_2 and Ar_3 may be preferably a phenyl group, a C_1 - C_{10} alkylphenyl group, a C_1 - C_{10} alkoxyphenyl group, a halophenyl group, a cyanophenyl group, a dicyanophenyl group, a trifluoromethoxyphenyl group, an o-, m-, or p-tolyl group, an o-, m- or p-cumenyl group, a mesityl group, a phenoxyphenyl group, a (α,α -dimethylbenzene)phenyl group, a (N,N'-dimethyl)aminophenyl group, a (N,N'-diphenyl)aminophenyl group, a (C_1 - C_{10} alkylcyclohexyl)phenyl group, an (anthracenyl)phenyl group, a biphenyl group, a C_1 - C_{10} alkylbiphenyl group, a C_1 - C_{10} alkoxybiphenyl group, a pentalenyl

group, an indenyl group, a naphthyl group, a C₁-C₁₀ alkynaphthyl group, a C₁-C₁₀ alkoynaphthyl group, a halonaphthyl group, a cyanonaphthyl group, a biphenylenyl group, a C₁-C₁₀ alkyl biphenylenyl group, a C₁-C₁₀ alkoxy biphenylenyl group, an anthracenyl group, an azulenyl group, a heptalenyl group, an acenaphthylenyl group, a phenalenyl group, a fluorenyl group, an anthraquinolyl group, a methylanthyryl group, a phenanthrenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, an ethyl-chrysenyl group, a picenyl group, a perylenyl group, a chloroperylene group, a pentaphenyl group, a pentacenyl group, a tetraphenylenyl group, a hexaphenyl group, a hexacenyl group, a rubicenyl group, a coronenyl group, a trinaphthylenyl group, a heptaphenyl group, a heptacenyl group, a pyranthrenyl group, an ovalenyl group, a carbazolyl group, a C₁-C₁₀ alkyl carbazolyl group, a thiophenyl group, an indolyl group, a purinyl group, a benzimidazolyl group, a quinoliny group, a benzothiophenyl group, a parathiazinyl group, a pyrrolyl group, a pyrazolyl group, an imidazolyl group, an imidazoliny group, an oxazolyl group, a thiazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a pyridinyl group, a pyridazinyl group, a pyrimidinyl group, a pyrazinyl group, and a thianthrenyl group.

[0051] More particularly, preferred compounds represented by formula (1), (2) or (3) are each independently one of compounds 1 to 62 below.

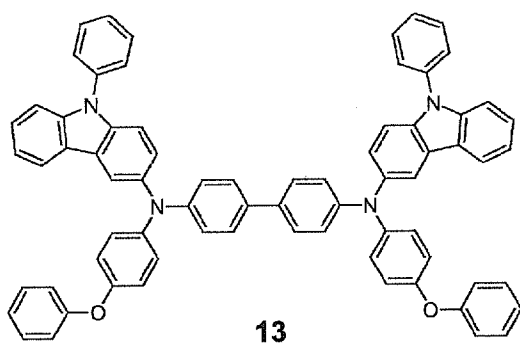
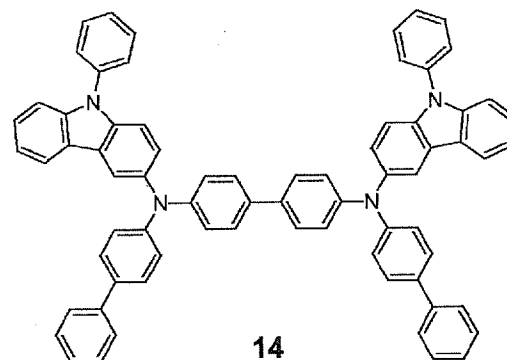




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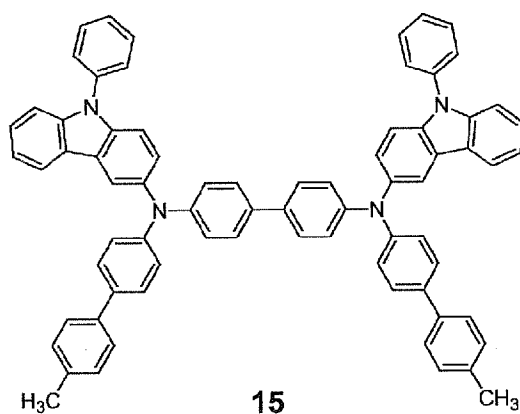
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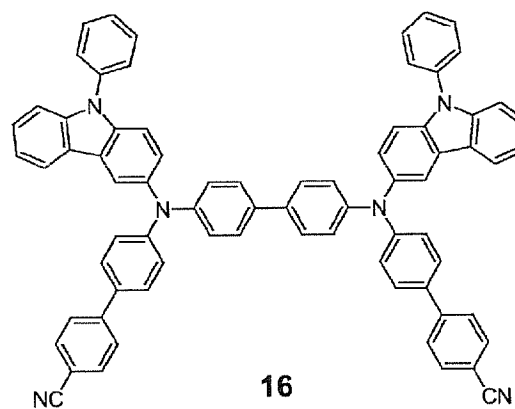
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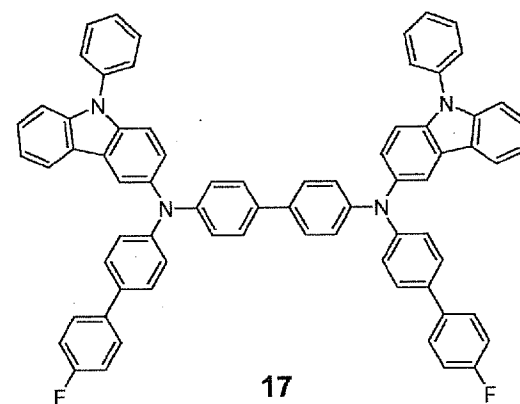
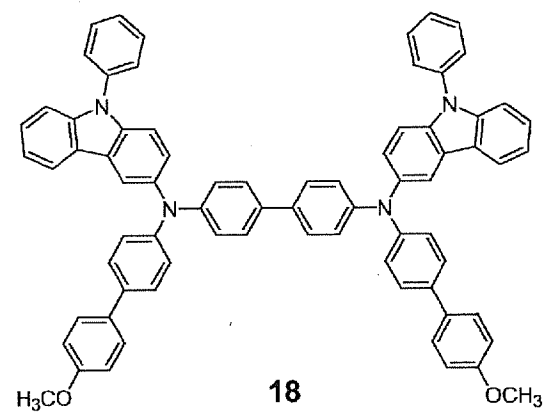
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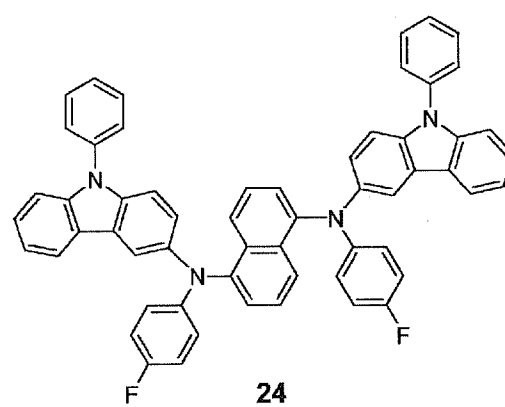
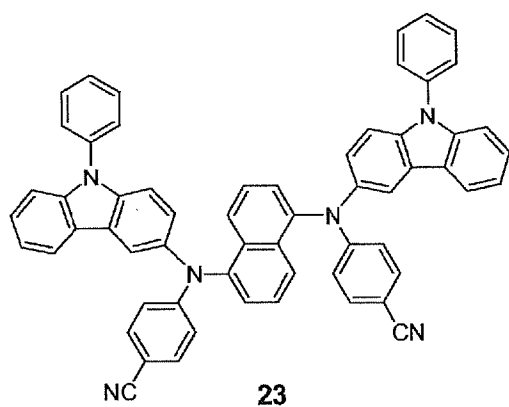
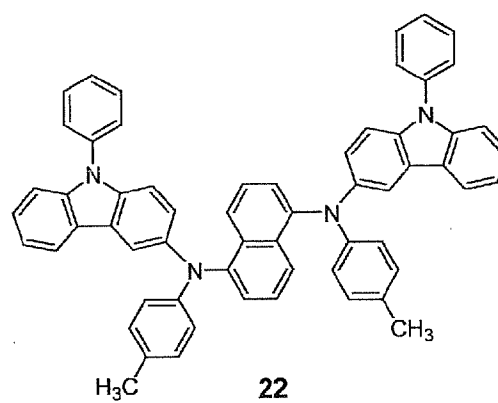
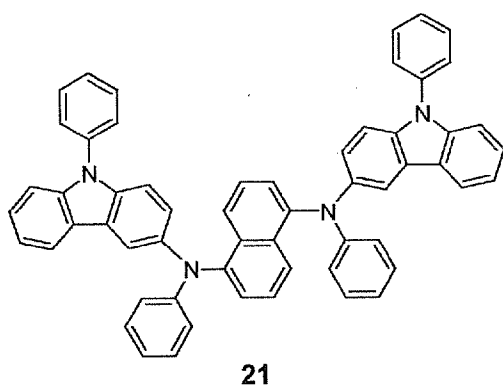
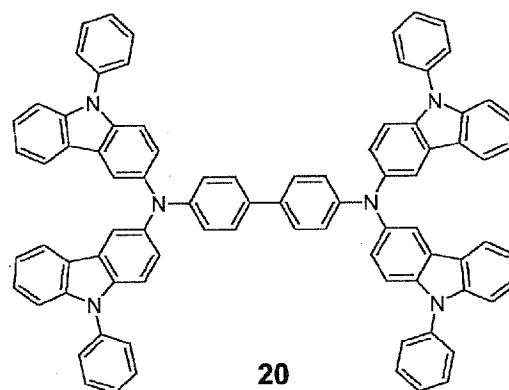
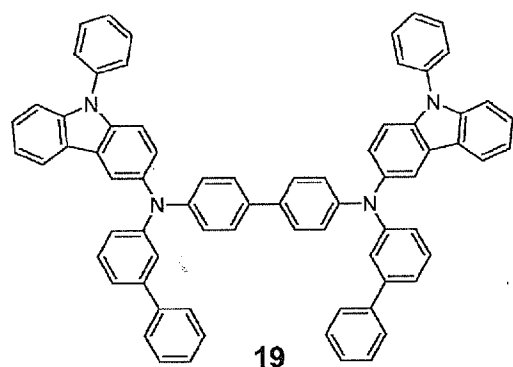
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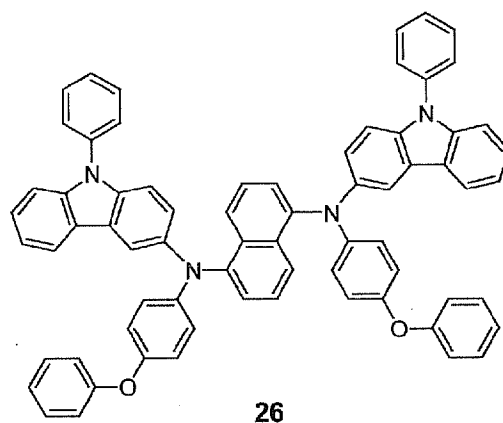
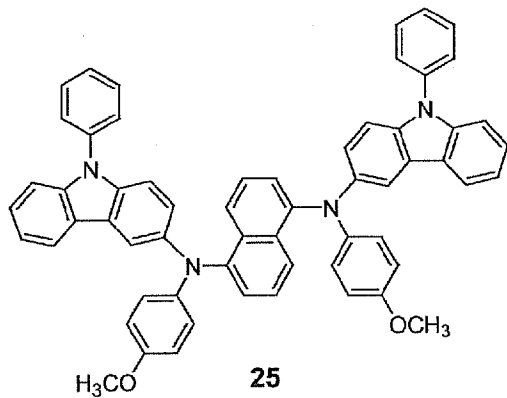
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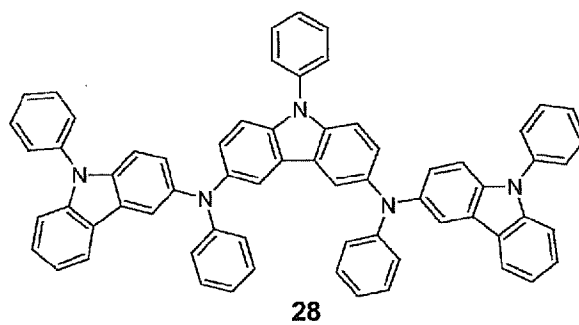
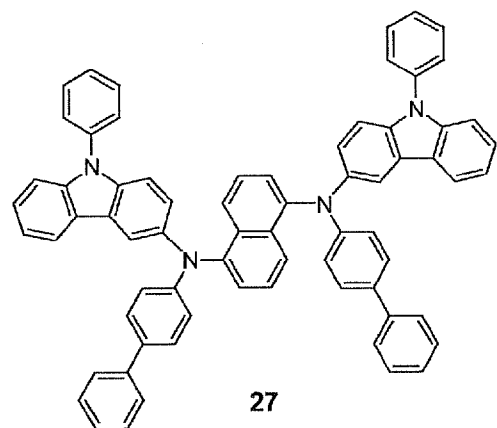
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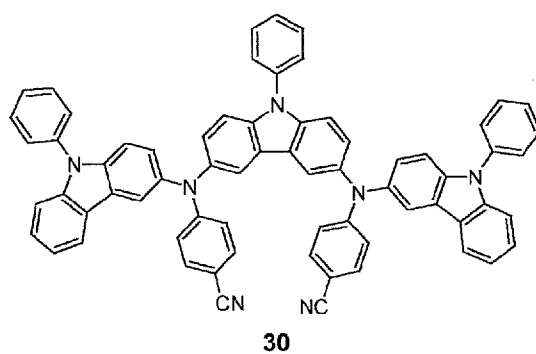
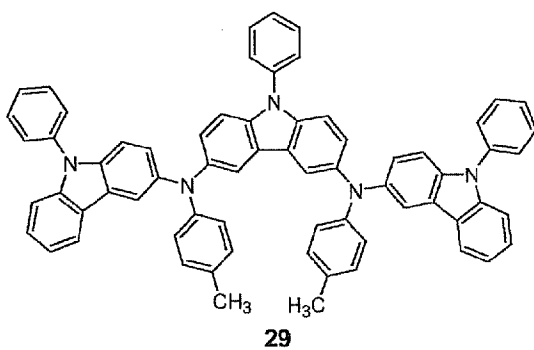
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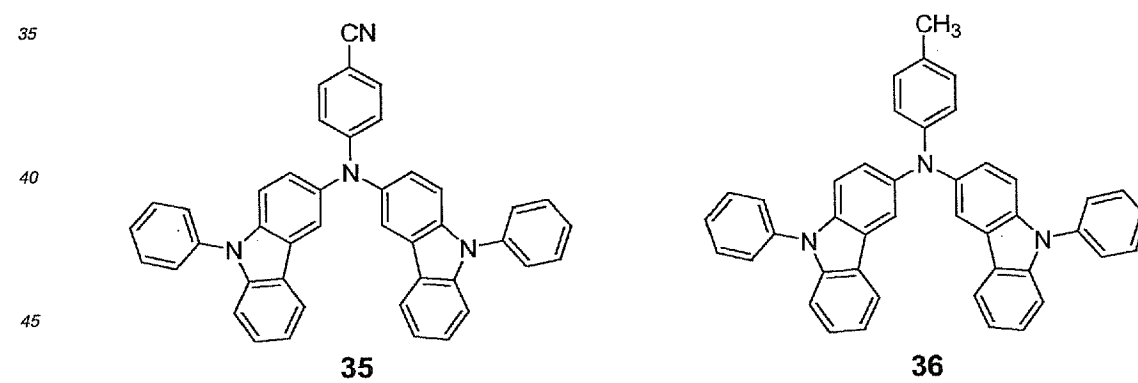
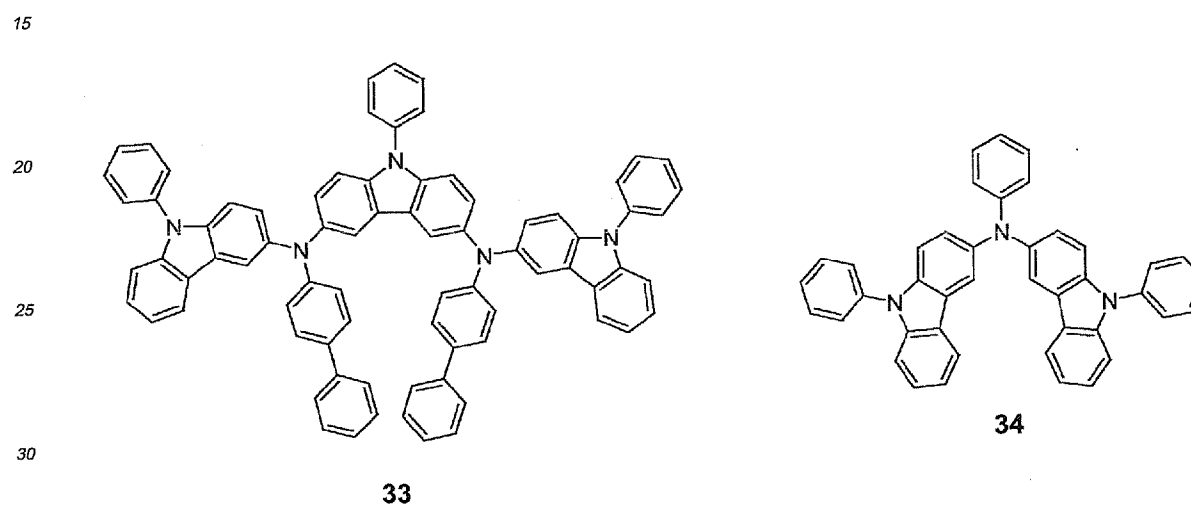
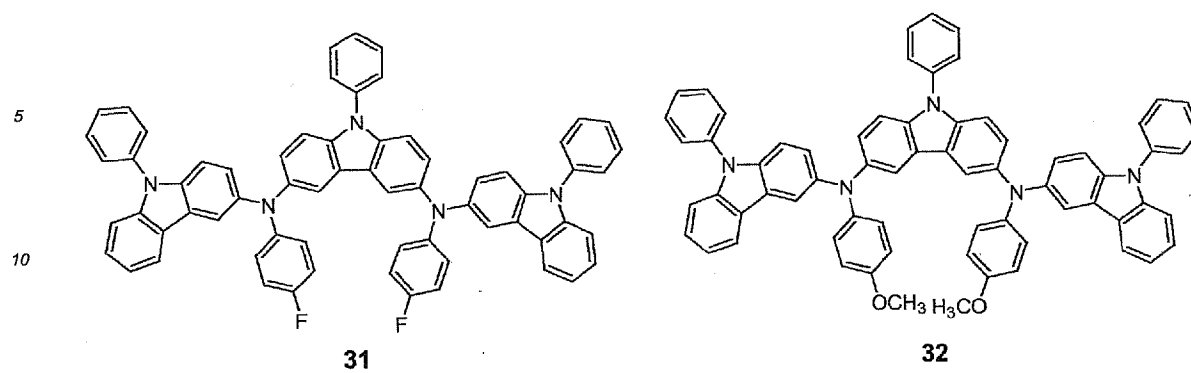
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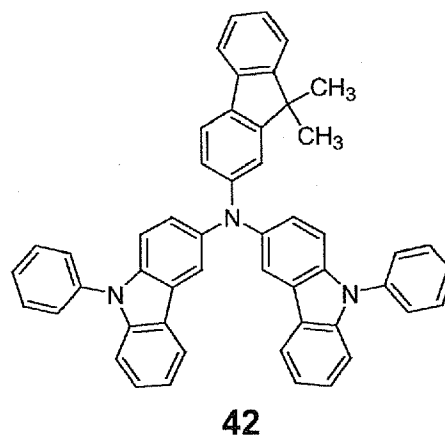
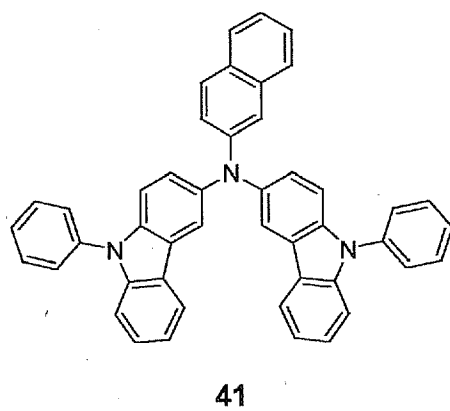
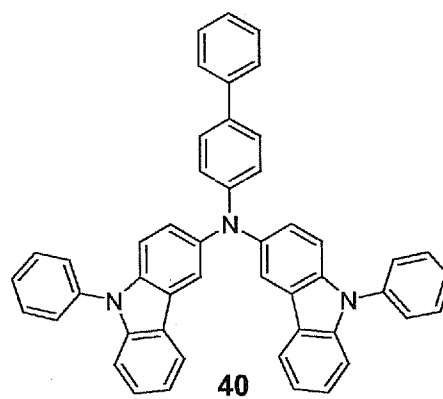
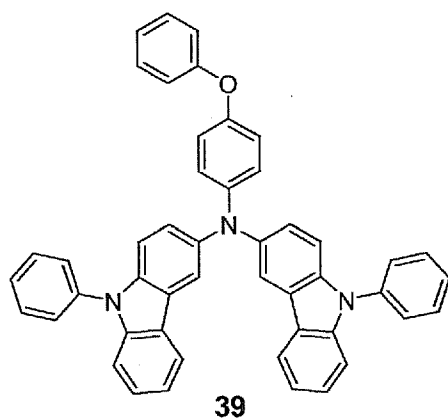
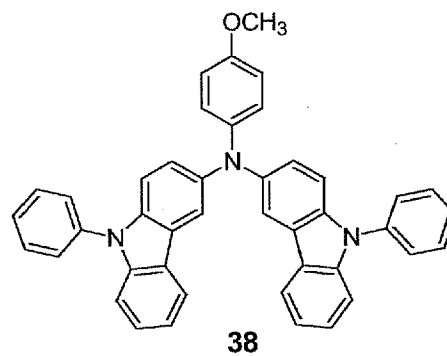
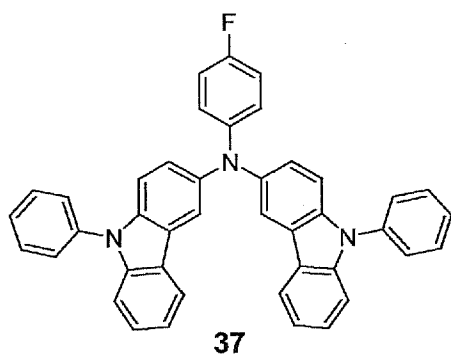
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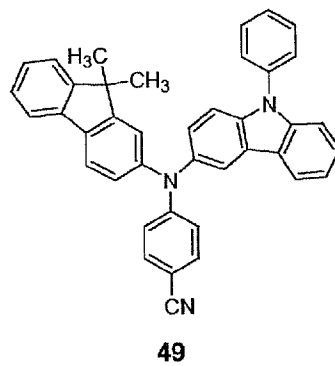
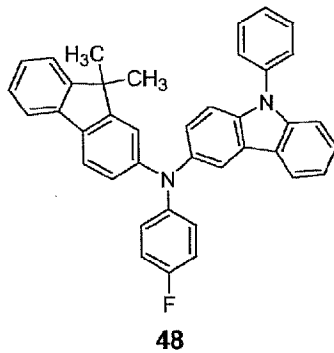
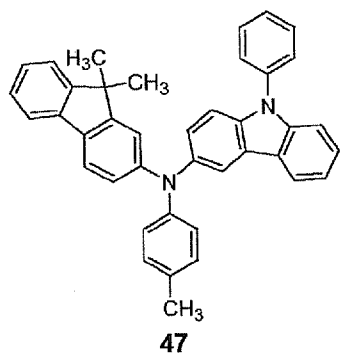
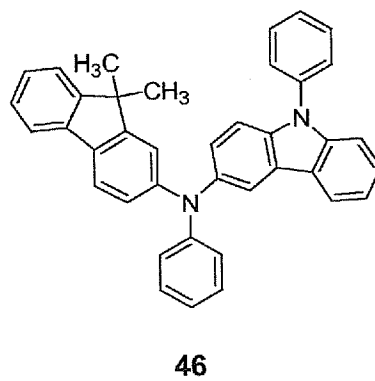
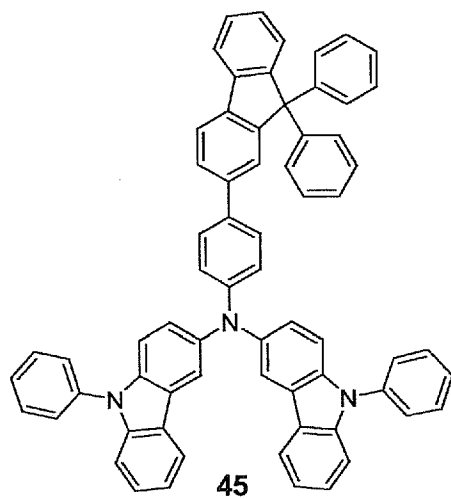
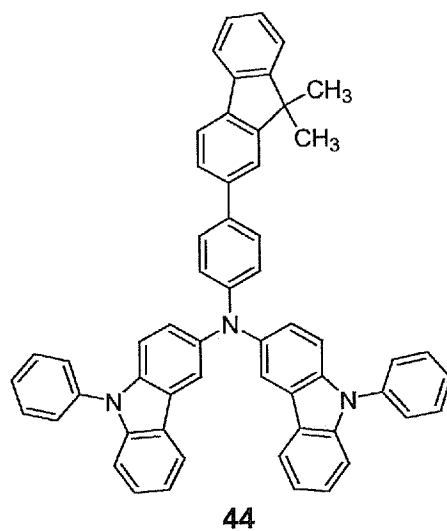
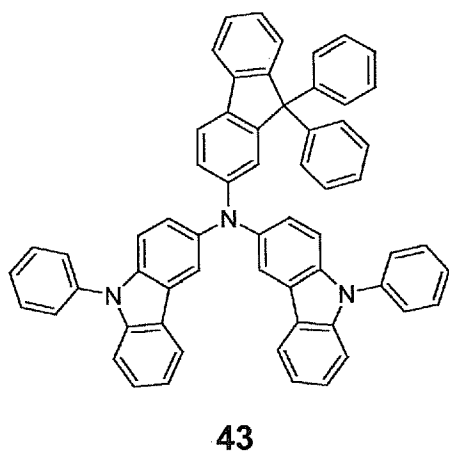
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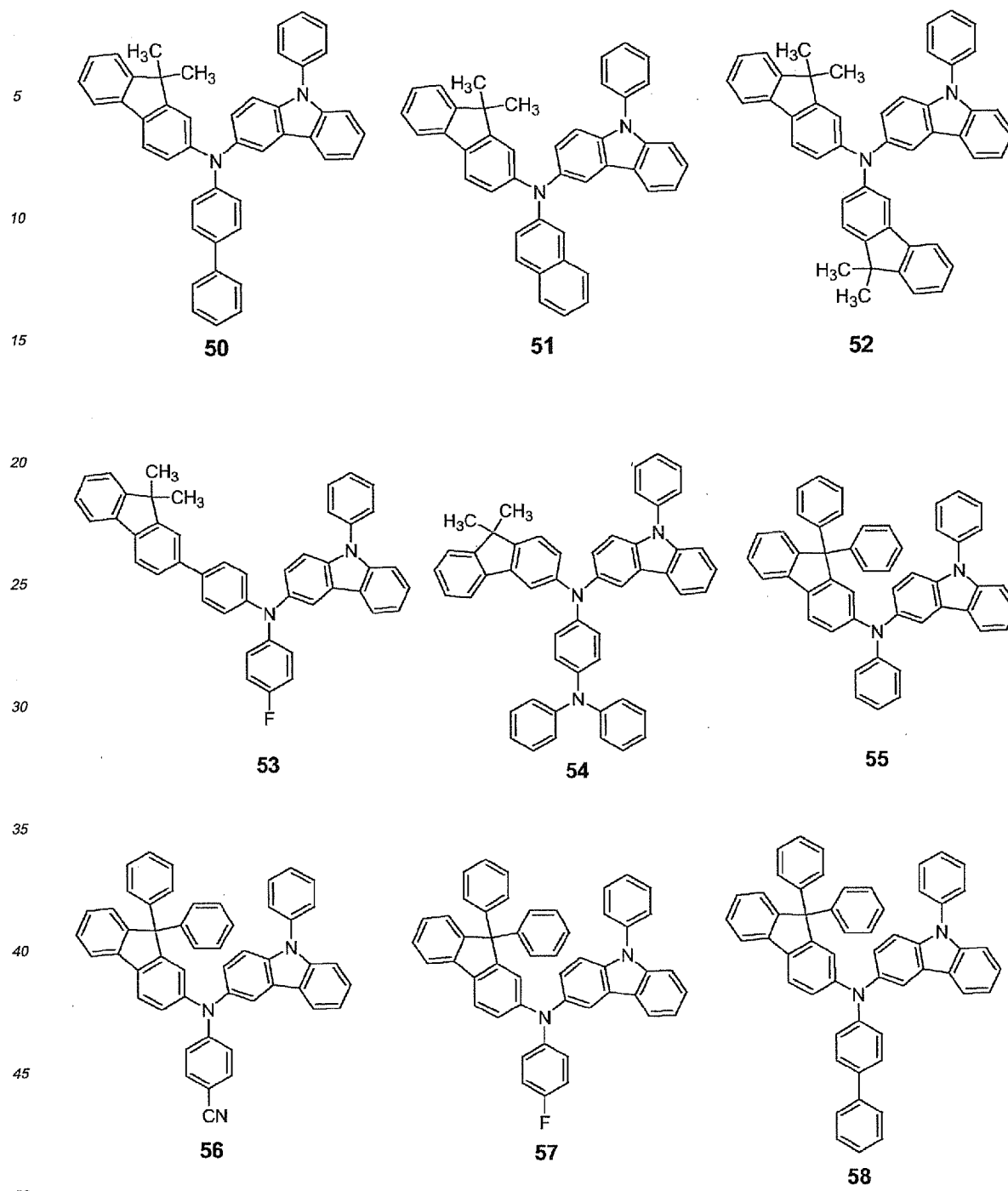
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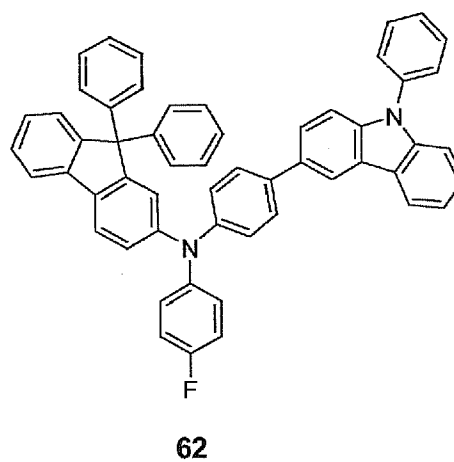
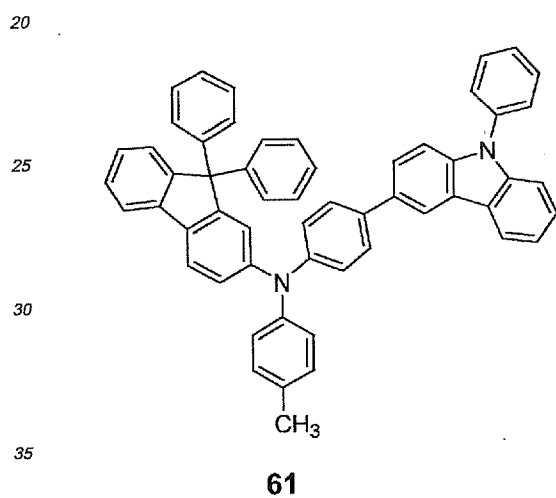
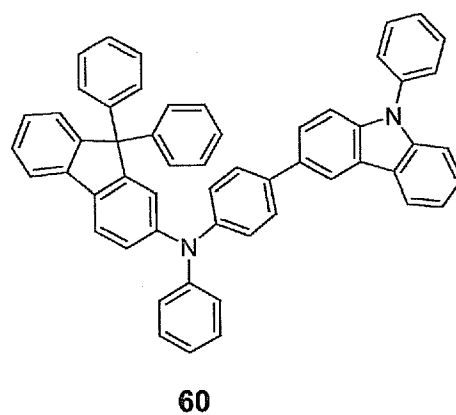
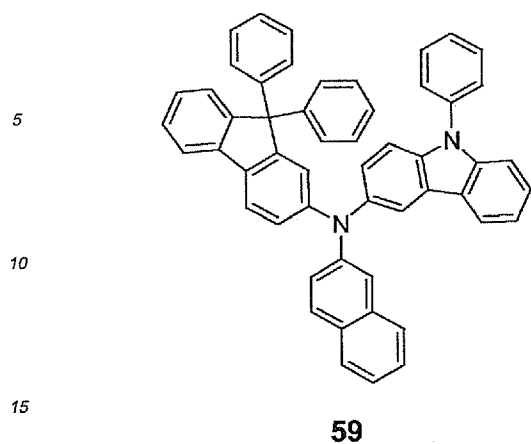
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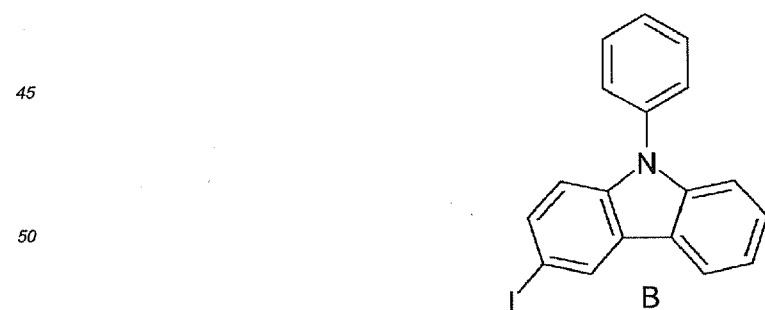




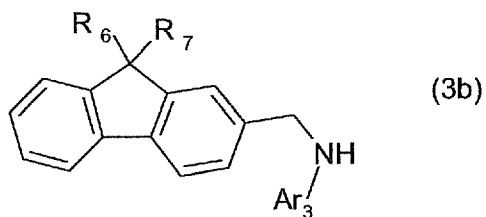
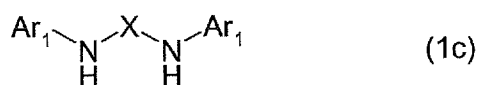




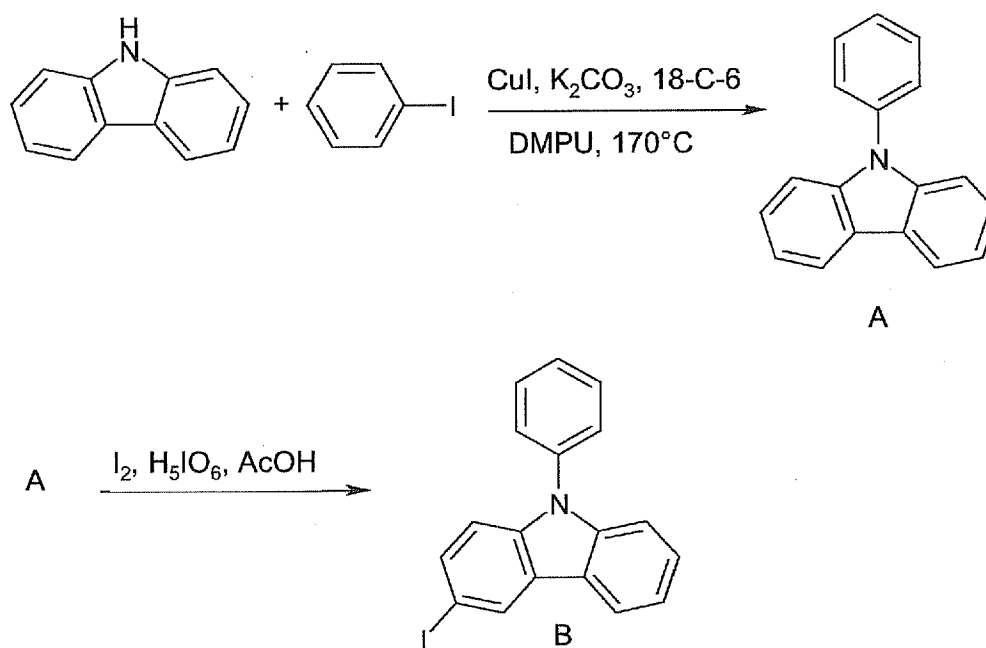
40 **[0052]** The compound represented by formula (1), (2) and (3c) may be synthesized by coupling a compound of formula B



55 via a palladium catalyzed coupling reaction with a primary or secondary amine according to any one of formulae (1c), (2b) and (3b)

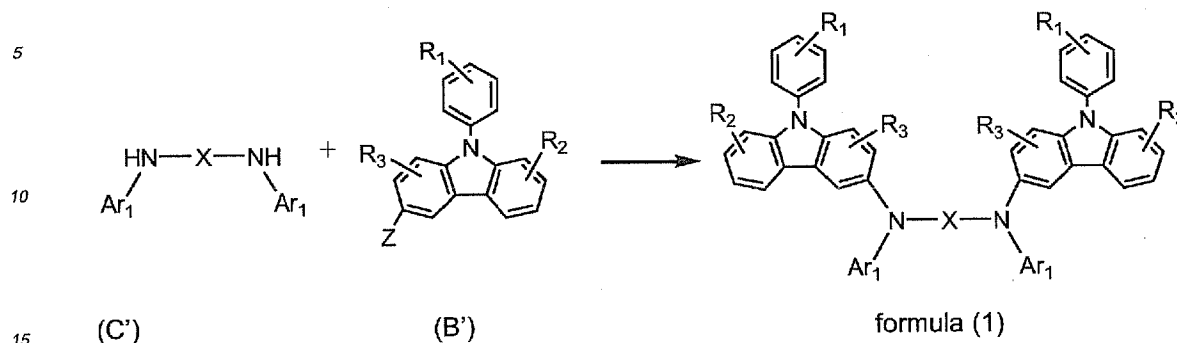


[0053] The intermediate B may be synthesized according to the following reaction scheme:



[0054] The compound represented by formula (1) may be synthesized through a reaction between a phenylcarbazole (B') with a diamine (C') according to Reaction Scheme 1 below.

Reaction Scheme 1



[0055] Here, X, R₁, R₂, R₃, and Ar₁ are already described above and Z can be a halogene, particularly iodine (I). The reaction can be performed in the presence of Pd₂(dba)₃ (dba = dibenzylideneacetone), sodium tert-butoxide and tri(tert-butyl)phosphine and at a reaction temperatures in the range of 50 to 150.

[0056] The layer which is included in the organic layer and which includes at least one of the compounds represented by formula (1), (2) or (3) may be a hole injection layer, a hole transport layer, or a single layer having hole injecting and transporting properties.

[0057] For example, the layer included in the organic layer and including at least one of the compounds represented by formula (1), (2) or (3) may be a hole injection layer.

[0058] The thickness of the hole injection layer formed under the red emission layer may be in the range of 1,600 to 2,200 Å, and preferably 1,900 to 2,200 Å. When the thickness of the hole injection layer formed under the red emission region is within the ranges described above, hole injecting and transporting properties suitable for causing resonance in a red emission layer of the organic layer can be obtained, and thus color purity, efficiency of the device, and a driving voltage of the device may be improved. In certain embodiments, the thickness of the hole injection layer formed under the red emission layer may be 1600, 1620, 1640, 1660, 1680, 1700, 1720, 1740, 1760, 1780, 1800, 1820, 1840, 1860, 1880, 1900, 1920, 1940, 1960, 1980, 2000, 2020, 2040, 2060, 2080, 2100, 2120, 2140, 2160, 2180, or 2200 Å. In some embodiments, the thickness of the hole injection layer formed under the red emission layer may be within a range defined by two of the foregoing thicknesses.

[0059] The thickness of the hole injection layer formed under the green emission region may be in the range of 1,400 to 1,800 Å, and preferably 1,600 to 1,800 Å. When the thickness of the hole injection layer is within the ranges described above, hole injecting and transporting properties suitable for causing resonance in a green emission layer of the organic layer can be obtained, and thus color purity, efficiency of the device, and the driving voltage of the device may be improved. In certain embodiments, the thickness of the hole injection layer formed under the green emission layer may be 1400, 1420, 1440, 1460, 1480, 1500, 1520, 1540, 1560, 1580, 1600, 1620, 1640, 1660, 1680, 1700, 1720, 1740, 1760, 1780, or 1800 Å. In some embodiments, the thickness of the hole injection layer formed under the green emission layer may be within a range defined by two of the foregoing thicknesses.

[0060] The thickness of the hole injection layer formed under the blue emission region may be in the range of 1,000 to 1,400 Å, and preferably 1,100 to 1,300 Å. When the thickness of the hole injection layer formed under the blue emission region is within the ranges described above, hole injecting and transporting properties suitable for causing resonance in a blue emission layer of the organic layer can be obtained, and thus color purity, efficiency of the device, and the driving voltage of the device may be improved. In certain embodiments, the thickness of the hole injection layer formed under the blue emission layer may be 1000, 1020, 1040, 1060, 1080, 1100, 1120, 1140, 1160, 1180, 1200, 1220, 1240, 1260, 1280, 1300, 1320, 1340, 1360, 1380, or 1400 Å. In some embodiments, the thickness of the hole injection layer formed under the blue emission layer may be within a range defined by two of the foregoing thicknesses.

[0061] The organic layer may further include a hole transport layer.

[0062] The total thickness of a region of the hole injection layer formed under a red emission region and the hole transport layer may be in the range of 2,000 to 2,400 Å, and preferably 2,100 to 2,300 Å. The thickness of the region of the hole injection layer formed under a red emission region may be in the range of 1,600 to 2,200 Å, and preferably 1,900 to 2,200 Å. When the total thickness of the region of the hole injection layer formed under the red emission region and the hole transport layer and/or the thickness of the region of the hole injection layer formed under the red emission region are within the ranges described above, hole injecting and transporting properties suitable for causing resonance in the red emission layer can be obtained, and thus color purity, efficiency of the device, and the driving voltage of the

device may be improved. In certain embodiments, total thickness of a region of the hole injection layer formed under the red emission region and the hole transport layer may be, 2000, 2020, 2040, 2060, 2080, 2100, 2120, 2140, 2160, 2180, 2200, 2220, 2240, 2260, 2280, 2300, 2320, 2340, 2360, 2380, or 2400 Å. In some embodiments, the total thickness of the hole injection layer and the hole transport layer formed under the red emission layer may be within a range defined by two of the foregoing thicknesses.

[0063] The total thickness of a region of the hole injection layer formed under a green emission region and the hole transport layer may be in the range of 1,600 to 2,000 Å, and preferably 1,700 to 1,900 Å. The thickness of the region of the hole injection layer formed under the green emission region may be in the range of 1,400 to 1,800 Å, and preferably 1,600 to 1,800 Å. When the total thickness of the region of the hole injection layer formed under the green emission region and the hole transport layer and/or the thickness of the region of the hole injection layer formed under the green emission region are within the ranges described above, hole injecting and transporting properties suitable for causing resonance in the green emission layer can be obtained, and thus color purity, efficiency of the device, and a driving voltage of the device may be improved. In certain embodiments, total thickness of a region of the hole injection layer formed under the green emission region and the hole transport layer may be, 1600, 1620, 1640, 1660, 1680, 1700, 1720, 1740, 1760, 1780, 1800, 1820, 1840, 1860, 1880, 1900, 1920, 1940, 1960, 1980, or 2000 Å. In some embodiments, the total thickness of the hole injection layer and the hole transport layer formed under the green emission layer may be within a range defined by two of the foregoing thicknesses.

[0064] The total thickness of a region of the hole injection layer formed under a blue emission region and the hole transport layer may be in the range of 1,200 to 1,600 Å, and preferably 1,300 to 1,500 Å. The thickness of the region of the hole injection layer formed under the blue emission region may be in the range of 1,000 to 1,400 Å, and preferably 1,100 to 1,300 Å. When the total thickness of the region of the hole injection layer formed under the blue emission region and the hole transport layer and/or the thickness of the region of the hole injection layer formed under the blue emission region are within the ranges described above, hole injecting and transporting properties suitable for causing resonance in the blue emission layer can be obtained, and thus color purity, efficiency of the device, and the driving voltage of the device may be improved. In certain embodiments, total thickness of a region of the hole injection layer formed under the blue emission region and the hole transport layer may be, 1200, 1220, 1240, 1260, 1280, 1300, 1320, 1340, 1360, 1380, 1400, 1420, 1440, 1460, 1480, 1500, 1520, 1540, 1560, 1580, or 1600 Å. In some embodiments, the total thickness of the hole injection layer and the hole transport layer formed under the blue emission layer may be within a range defined by two of the foregoing thicknesses.

[0065] An organic light emitting device according to an embodiment of the present invention includes: a substrate; a first electrode; a second electrode; and an organic layer interposed between the first electrode and the second electrode and comprising an emission layer having a red emission region and a hole injection layer having a region formed under the red emission region, wherein one of the first electrode and the second electrode is a reflective electrode and the other is a semitransparent or transparent electrode, and wherein the thickness of the region of the hole injection layer formed under the red emission region is in the range of 1,600 to 2,200 Å, and preferably 1,900 to 2,200 Å.

[0066] When the thickness of the region of the hole injection layer formed under the red emission region is within the ranges described above, hole injecting and transporting properties suitable for causing resonance in a red emission layer can be obtained, and thus color purity, efficiency of the device, and the driving voltage of the device may be improved.

[0067] An organic light emitting device according to an embodiment of the present invention includes: a substrate; a first electrode; a second electrode; and an organic layer interposed between the first electrode and the second electrode and comprising an emission layer having a green emission region and a hole injection layer having a region formed under the green emission region, wherein one of the first electrode and the second electrode is a reflective electrode and the other is a semitransparent or transparent electrode, and wherein the thickness of the region of the hole injection layer formed under the green emission region is in the range of 1,400 to 1,800 Å, and preferably 1,600 to 1,800 Å.

[0068] When the thickness of the region of the hole injection layer formed under the green emission region is within the ranges described above, hole injecting and transporting properties suitable for causing resonance in the green emission layer can be obtained, and thus color purity, efficiency of the device, the driving voltage of the device may be improved.

[0069] An organic light emitting device according to an embodiment of the present invention includes: a substrate; a first electrode; a second electrode; and an organic layer interposed between the first electrode and the second electrode and comprising an emission layer having a blue emission region and a hole injection layer having a region formed under the blue emission region, wherein one of the first electrode and the second electrode is a reflective electrode and the other is a semitransparent or transparent electrode, and wherein the thickness of the region of the hole injection layer formed under the blue emission region is in the range of 1,000 to 1,400 Å, and preferably 1,100 to 1,300 Å.

[0070] When the thickness of the region of the hole injection layer formed under the blue emission region is within the ranges described above, hole injecting and transporting properties suitable for causing resonance in the blue emission layer can be obtained, and thus color purity, efficiency of the device, and the driving voltage of the device may be improved.

[0071] Resonance can occur between the first electrode and the second electrode of an organic light emitting device

according to an embodiment of the present invention during the operation thereof. The hole injection layer of the organic layer disposed between the first electrode and the second electrode may have a specific thickness according to the color of the light emitted by the organic layer described above to obtain excellent properties such as driving voltage, current density, luminance, color purity, efficiency and lifetime of the organic light emitting device.

[0072] In an organic light emitting device according to an embodiment of the present invention, the first electrode can be formed on the substrate. The first electrode may be a reflective electrode and the second electrode may be a semitransparent or transparent electrode. Thus, resonance may occur between the first electrode and the second electrode during the operation of the device. Accordingly, the light generated in the organic layer between the first electrode and the second electrode resonates between the first electrode and the second electrode during the operation of the organic light emitting device, and the light is extracted through the second electrode, that is, in a direction away from the substrate.

[0073] The organic layer of the organic light emitting device may include an emission layer and/or a hole injection layer. The organic layer may further include at least one of a hole transport layer, an electron blocking layer, a hole blocking layer, an electron transport layer, and an electron injection layer. Thus, for example, an organic light emitting device according to an embodiment of the present invention may have a structure of substrate/first electrode/hole injection layer (HIL)/hole transport layer (HTL)/emission layer (EML)/hole blocking layer (HBL)/electron transport layer (ETL)/electron injection layer (EIL)/second electrode as illustrated in FIG. 1.

[0074] Hereinafter, Examples and methods of manufacturing an organic light emitting device according to an embodiment of the present invention will be described with reference to the organic light emitting device illustrated in FIGS. 1 and 2. FIG. 1 schematically illustrates a structure of an organic light emitting device according to an embodiment of the present invention. FIG. 2 schematically illustrates an organic light emitting device including red, green, and blue emission layers according to an embodiment of the present invention.

[0075] Referring to FIG. 2, a first electrode 210 is formed on a substrate 200. Here, the substrate 200, which can be any substrate that is commonly used in conventional organic light emitting devices, may be a glass substrate or a plastic substrate with excellent transparency, surface smoothness, ease of treatment, and that is waterproof.

[0076] The first electrode 210 may be a reflective electrode, a semitransparent electrode or a transparent electrode formed of a metal with excellent conductivity such as Li, Mg, Al, Al-Li, Ca, Mg-In, Mg-Ag, and Ca-Al, or a metal oxide with excellent conductivity such as ITO, IZO, and In_2O_3 . A combination of two or more of the metals or the metal oxides described above can also be used.

[0077] Then a pixel defining layer 214 which defines regions in which red, green, and blue emission layers will be formed is formed on predetermined regions. The pixel defining layer 214 can be formed by deposition or coating, etc. using inorganic materials such as a silicon oxide and a nitride or organic materials having insulating properties.

[0078] Then, a HIL 216 and a HTL 218 are sequentially formed on the first electrode 210 by thermal evaporation or spin coating according to regions which are defined by the pixel defining layer 214.

[0079] The HIL 216 may include at least one of the compounds represented by Formulae 1, 2, and 3. The HTL 218 may include 1,3,5-tricarbazolylbenzene, 4,4'-biscarbazolylbiphenyl, polyvinylcarbazole, m-biscarbazolylphenyl, 4,4'-biscarbazolyl-2,2'-dimethylbiphenyl, 4,4',4"-tri(N-carbazolyl)triphenylamine, 1,3,5-tri(2-carbazolylphenyl)benzene, 1,3,5-tris(2-carbazolyl-5-methoxyphenyl)benzene, bis(4-carbazolylphenyl)silane, N,N'-bis(3-methylphenyl)-N,N'-diphenyl-[1,1'-biphenyl]-4,4'-diamine (TPD), N,N'-di(naphthalene-1-yl)-N,N'-diphenylbenzidine (α -NPD), N,N'-diphenyl-N,N'-bis(1-naphthyl)-(1,1'-biphenyl)-4,4'-diamine(NPB), IDE 320 (Idemitsu Corporation), poly(9,9-dioctylfluorene-co-N-(4-butylphenyl)diphenylamine (TFB), or poly(9,9-dioctylfluorene-co-bis-(4-butylphenyl-bis-N,N-phenyl-1,4-phenylenediamin (PFB), but is not limited to the above-described examples.

[0080] The thickness of the HIL 216 and the HTL 218 are described above.

[0081] The HIL 216 can be formed using a known method such as vacuum deposition, spin coating, casting, Langmuir Blodgett (LB), or the like.

[0082] When the HIL 216 is formed by vacuum deposition, vacuum deposition conditions may vary according to a compound that is used to form the HIL 216, and the structure and thermal properties of the HIL 216 to be formed. In general, however, conditions for vacuum deposition may include a deposition temperature of 100-500°C, a pressure of 10^{-8} - 10^{-3} torr, and a deposition speed of 0.01-100 Å/sec.

[0083] When the HIL 216 is formed by spin coating, coating conditions may vary according to a compound that is used to form the HIL 216, and the structure and thermal properties of the HIL 216 to be formed. In general, however, the coating speed may be in the range of about 2000 to 5000 rpm, and a temperature for heat treatment, which is performed to remove a solvent after coating may be in the range of about 80 to 200°C.

[0084] The HTL 218 can be formed using a known method such as vacuum deposition, spin coating, casting, LB, or the like.

[0085] When the HTL 218 is formed by vacuum deposition and spin coating, conditions for deposition and coating are similar to those for formation of the HIL 216, although conditions for deposition and coating may vary according to a material that is used to form the HTL 218.

[0086] Red, green and blue EMLs, 220, 225, and 230 are formed on the HTL 218. The material used to form the red, green and blue EMLs, 220, 225, and 230 is not limited.

[0087] For example, DCM1, DCM2, Eu(thenoyltrifluoroacetone)₃ (Eu(TTA)₃), and butyl-6-(1,1,7,7-tetramethyljulolidyl-9-enyl)-4H-pyran (DCJTB) can be used to form the red EML 220. Alternatively, a dopant such DCJTB can be deposited with Alq₃, Alq₃ and rubrene can be co-deposited and a dopant can be deposited thereon, or dopants such as BTPir or RD 61 can be deposited with 4,4'-N,N'-dicarbazole-biphenyl (CBP) to form the red EML 220, but the present invention is not limited to the above-described examples.

[0088] For example, Coumarin 6, C545T, quinacridone, and Ir(ppy)₃ can be used to form the green EML 225. Alternatively, a dopant such Ir(ppy)₃ can be deposited with CBP, or a dopant such as a coumarin-based material can be deposited with Alq₃ as a host to form the green EML 225, but the present invention is not limited to the above-described examples. Examples of the coumarin-based dopant may include C314S, C343S, C7, C7S, C6, C6S, C314T, and C545T.

[0089] For example, oxadiazole dimer dyes (Bis-DAPOXP), spiro compounds (Spiro-DPVBi, Spiro-6P), triarylamine compounds, bis(styryl) amine (DPVBi, DSA), CzTT, Anthracene, TPB, PCP, DST, TPA, OXD-4, BBOT, AZM-Zn, and BH-013X (Idemitsu Corporation) which is an aromatic hydrocarbon compound containing a naphthalene moiety can be used to form the blue EML 230. Alternatively, a dopant such IDE 105 (Idemitsu Corporation) can be deposited on IDE 140 (Idemitsu Corporation) to form the blue EML 230, but the present invention is not limited to the above-described examples.

[0090] The thickness of the red, green and blue EMLs, 220, 225 and 230 may be in the range of 200 to 500 Å, and preferably 300 to 400 Å. The thickness of each of the red, green and blue, EMLs, 220, 225 and 230 may be the same or different. When the thickness of the red, green and blue, EMLs, 220, 225 and 230 is within the ranges described above, excellent lifetime and driving voltage of the light emitting device may be obtained.

[0091] The red, green and blue, EMLs, 220, 225 and 230 can be formed using a known method such as vacuum deposition, spin coating, casting, LB, or the like. When the red, green and blue, EMLs, 220, 225 and 230 are formed by vacuum deposition and spin coating, conditions for deposition and coating are similar to those for formation of the HIL 216, although conditions for deposition and coating may vary according to the material that is used to form the red, green and blue, EMLs, 220, 225 and 230.

[0092] A HBL (not shown) can optionally be formed on the red, green and blue, EMLs, 220, 225 and 230 by vacuum deposition or spin coating. A material that is used to form the HBL should have a capability of transporting electrons and an ionization potential higher than the red, green and blue, EMLs, 220, 225 and 230, and thus examples of the material may include bis(2-methyl-8-quinolato)-(p-phenylphenolato)-aluminum (Balq), bathocuproine (BCP), and tris(N-aryl benzimidazole) (TPBI), but are not limited thereto.

[0093] The thickness of the HBL may be in the range of 30 to 60 Å, and preferably 40 to 50 Å. When the thickness of the HBL is within the ranges described above, a proper hole blocking capability and the driving voltage of the device may be obtained.

[0094] The HBL can be formed using a known method such as vacuum deposition, spin coating, casting, LB, or the like. When the HBL is formed by vacuum deposition and spin coating, conditions for deposition and coating are similar to those for formation of the HIL 216, although conditions for deposition and coating may vary according to the material that is used to form the HBL.

[0095] An ETL 240 can be optionally formed by vacuum deposition or spin coating on the red, green and blue, EMLs, 220, 225 and 230, or the HBL. The material that is used to form the ETL 240 may be Alq₃, but is not limited thereto.

[0096] The thickness of the ETL 240 may be in the range of about 100 to 400 Å, and preferably, 250 to 350 Å. When the thickness of the ETL 240 is greater than 100 Å, proper charge balance can be maintained. On the other hand, when the thickness of the ETL 240 is less than 400 Å, proper driving voltage of the device may be obtained.

[0097] The ETL 240 can be formed using a known method such as vacuum deposition, spin coating, casting, LB, or the like. When the ETL 240 is formed by vacuum deposition and spin coating, conditions for deposition and coating are similar to those for formation of the HIL 216, although conditions for deposition and coating may vary according to the material that is used to form the ETL 240.

[0098] An EIL 250 may be formed by vacuum deposition or spin coating on the ETL 240. The material that is used to form the EIL 250 may be BaF₂, LiF, NaCl, CsF, Li₂O, BaO, Liq, or the like, but is not limited thereto.

[0099] The thickness of the EIL 250 may be in the range of 2 to 100 Å, preferably, 2 to 5 Å, and more preferably 2 to 4 Å. When the thickness of the EIL 250 is within the ranges described above, proper electron injecting capability and the driving voltage of the device may be obtained.

[0100] The EIL 250 can be formed using a known method such as vacuum deposition, spin coating, casting, LB, or the like. When the EIL 250 is formed by vacuum deposition and spin coating, conditions for deposition and coating are similar to those for formation of the HIL 216, although conditions for deposition and coating may vary according to the material that is used to form the EIL 250.

[0101] A second electrode 260 is formed on the EIL 250 by deposition to thereby complete the manufacture of the organic light-emitting device according to the current embodiment of the present invention.

[0102] The material that is used to form the second electrode 260 can be a transparent metal oxide with excellent conductivity such as ITO, IZO, SnO_2 , and ZnO . Li, Mg, Al, Al-Li, Ca, Mg-In, Mg-Ag, Ca-Al can be used to form a thin film of the second electrode 260, and thus the second electrode 260 can be a reflective electrode, a semitransparent electrode, or a transparent electrode in a various manner. The material used to form the second electrode 260 is not limited to the above-described examples.

[0103] The first electrode 210 and the second electrode 260 can be an anode or a cathode.

[0104] The organic light emitting device according to the current embodiment of the present invention can be utilized in various types of flat panel display devices such as a passive matrix organic light emitting device and an active matrix organic light emitting device. When the organic light emitting device of the present embodiment is utilized in an active matrix organic light emitting device, the first electrode 210 as a pixel electrode that is formed on the substrate 200 can be electrically connected to a source electrode or a drain electrode of a thin film transistor. The organic light emitting device of the present embodiment can also be utilized in a flat panel display that can realize images in two sides.

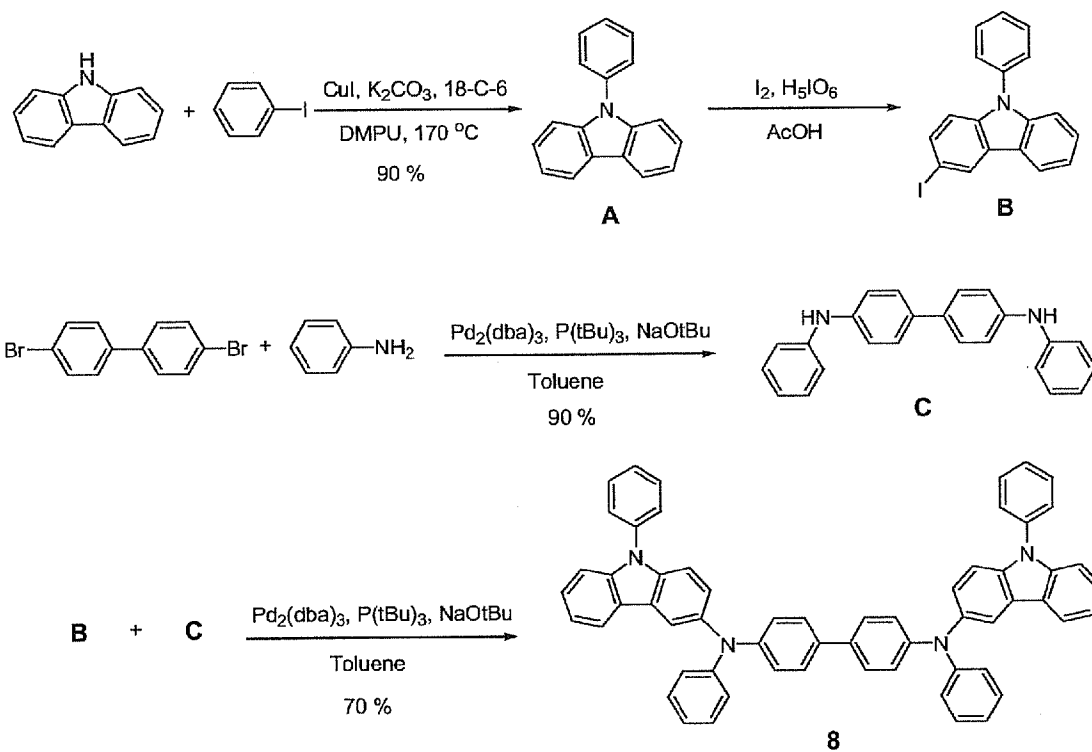
[0105] Hereinafter, the present invention will be described more specifically with reference to the following Synthesis Examples of Compounds 8, 9, 10, 11, 14, 28, 35, and 56 and Examples of an organic light emitting device according to an embodiment of the present invention will now be described in detail. However, the Synthesis Examples and the Examples are not intended to limit the scope of the present invention.

Examples

Synthesis Example 1: Synthesis of Compound 8

[0106] Compound 8 was synthesized through Reaction Scheme 2 below.

Reaction Scheme 2



Synthesis of Intermediate A

[0107] 16.7 g (100 mmol) of carbazole, 26.5 g (130 mmol) of iodobenzene, 1.9 g (10 mmol) of CuI, 138 g (1 mol) of K_2CO_3 , and 530 mg (2 mmol) of 18-crown-6 were dissolved in 500 ml of 1,3-Dimethyl-3,4,5,6-tetrahydro-(1H)-pyrimidinone (DMPU), and heated at 170°C for 8 hours.

[0108] After the reaction terminated, the reaction mixture was cooled to room temperature, and the resultant solid substance was filtered. Then a small amount of ammonium hydroxide was added to the filtered solution. The resultant was washed three times with 300 ml of diethylether, and dried in $MgSO_4$ under reduced pressure. As a result, a crude product was obtained. The crude product was purified using a silica gel column chromatography to produce 22 g of Intermediate A as a white solid (yield 90%).

[0109] 1H NMR ($CDCl_3$, 400MHz) δ (ppm) 8.12 (d, 2H), 7.58-7.53 (m, 4H), 7.46-7.42 (m, 1 H), 7.38 (d, 4H), 7.30-7.26 (m, 2H); ^{13}C NMR ($CDCl_3$, 100MHz) δ (ppm) 141.0, 137.9, 130.0, 127.5, 127.3, 126.0, 123.5, 120.4, 120.0, 109.9.

Synthesis of Intermediate B

[0110] 2.433 g (10 mmol) of Intermediate A was added to 100 ml of 80% acetic acid. 1.357 g (5.35 mmol) of iodine (I_2) and 0.333 g (1.46 mmol) of o-periodic acid (H_5IO_6) were added thereto in the solid state. Then, the mixture was stirred at 80°C in a nitrogen atmosphere for 2 hours.

[0111] After the reaction terminated, the resultant solution was extracted three times with 50 ml of ethylether. An organic layer collected from the mixture was dried over $MgSO_4$ to evaporate the solvent. As a result, the dried result was purified using a silica gel column chromatography to produce 3.23 g of Intermediate B as a white solid (yield 87%).

[0112] 1H NMR ($CDCl_3$, 300MHz) δ (ppm) 8.43 (d, 1H), 8.05 (d, 1H), 7.62 (dd, 1H), 7.61-7.75 (m, 2H), 7.51-7.43 (m, 3H), 7.41-7.35 (m, 2H), 7.27 (dd, 1 H), 7.14 (d, 1 H)

Synthesis of Intermediate C

[0113] 3.12 g (10 mmol) of 4,4'-dibromodiphenyl, 2.3 ml (25 mmol) of aniline, 2.9 g (30 mmol) of t-BuONa, 183 mg (0.2 mmol) of $Pd_2(dba)_3$, 20 mg (0.1 mmol) of P(t-Bu) $_3$ were dissolved in 30 ml of toluene and the mixture was stirred at 90° C for 3 hours.

[0114] The reaction mixture was cooled to room temperature, and the resultant solution was extracted three times with 30 ml of distilled water and diethylether. A precipitate in an organic layer was filtered, washed with acetone and diethylether, and dried in a vacuum condition to produce 0.3 g of Intermediate C (yield 90%).

[0115] 1H NMR ($DMSO-d_6$, 400MHz) δ (ppm) 8.22 (s, 2H), 7.48 (d, 4H), 7.23 (t, 4H), 7.10 (dd, 8H), 6.82 (t, 2H); ^{13}C NMR ($DMSO-d_6$, 100MHz) δ (ppm) 145.7, 144.3, 133.7, 131.4, 128.7, 121.2, 119.2, 118.9.

Synthesis of Compound 8

[0116] 912 mg (2.47 mmol) of Intermediate B, 336.4 mg (1 mmol) of Intermediate C, 300 mg (3 mmol) of t-BuONa, 40 mg (0.02 mmol) of $Pd_2(dba)_3$, 3 mg (0.01 mmol) of P(t-Bu) $_3$ were dissolved in 5 ml of toluene and the mixture was stirred at 90° C for 3 hours.

[0117] After the reaction terminated, the resultant mixture was cooled to room temperature, and the resultant solution was extracted three times with distilled water and 30 ml of ethylether. An organic layer collected from the mixture was dried over $MgSO_4$ to evaporate the solvent. As a result, the dried result was purified using a silica gel column chromatography to produce 570 mg of Compound 8 as a yellow solid (Yield 70%).

[0118] 1H NMR ($CDCl_3$, 300MHz) δ (ppm) 7.99 (d, 2H), 7.95 (s, 2H), 7.61-7.57 (m, 8H), 7.48-7.32 (m, 12H), 7.27-7.19 (m, 8H), 7.18-7.10 (m, 8H), 6.96 (t, 2H); ^{13}C NMR ($CDCl_3$, 100MHz) δ (ppm) 148.4, 147.3, 141.3, 140.4, 138.0, 137.6, 133.9, 129.9, 129.1, 127.4, 127.1, 127.0, 126.1, 125.6, 124.3, 123.0, 122.9, 122.8, 121.7, 120.5, 119.9, 118.5, 110.7, 109.9.

[0119] Compound 8 was diluted in $CHCl_3$ to a concentration of 0.2 mM and a UV Spectrum of the diluted Compound 8 was obtained. Maximum absorption wavelengths were 353, 306 and 238 nm.

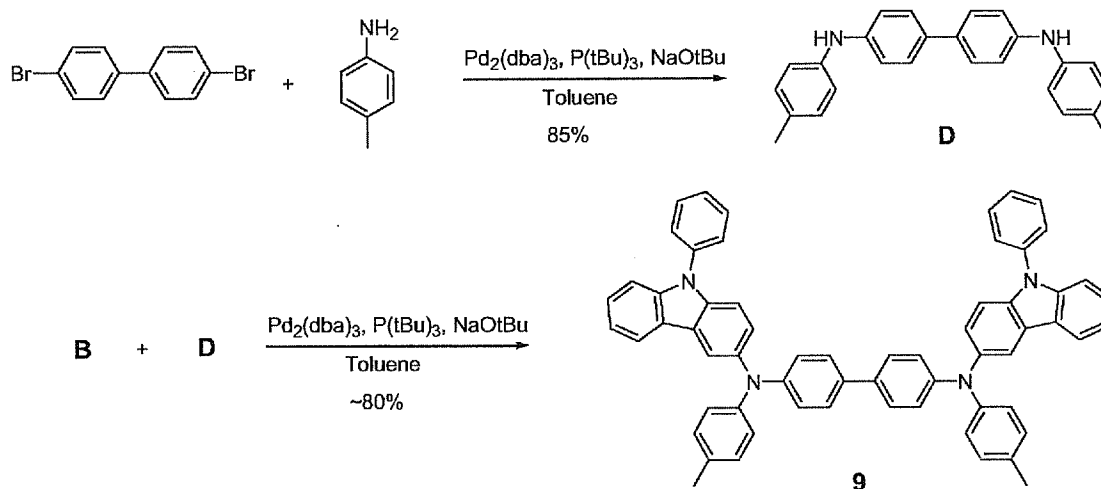
[0120] Td (decomposition temperature) and Tg (glass transition temperature) of Compound 8 were measured by performing thermal analysis using thermo gravimetric analysis (TGA) and differential scanning calorimetry (DSC) under the following conditions: N_2 atmosphere, temperatures of room temperature to 600°C (10°C/min)-TGA and of room temperature to 400°C-DSC, and Pan Type: Pt Pan in disposable Al Pan (TGA) and disposable Al pan (DSC). The measured Td was 494°C and Tg was 153°C.

[0121] A highest occupied molecular orbital (HOMO) level of 5.16 eV and a lowest occupied molecular orbital (LUMO) level of 2.16 eV were obtained using AC-2 that measures UV absorption spectrum and ionization potential.

Synthesis Example 2: Synthesis Compound 9

[0122] Compound 9 was synthesized through Reaction Scheme 3 below.

Reaction Scheme 3



[0123] Intermediate D was synthesized with a yield of 85% in the same manner as in Synthesis Example 1, except that p-tolylamine was used instead of aniline in the synthesis of Intermediate C of Synthesis Example 1. Then, 2 g (Yield 80%) of Compound 9 as a yellow solid was produced in the same manner as in Synthesis Example 1, except that Intermediate D was used instead of Intermediate C in the synthesis of Compound 8 of Synthesis Example 1.

[0124] ^1H NMR (C_6D_6 , 300MHz) δ (ppm) 8.14 (d, 2H), 7.64 (d, 2H), 7.47 (d, 4H), 7.38-7.28 (m, 6H), 7.27-7.25 (m, 8H), 7.23-7.01 (m, 16H), 6.96 (d, 2H), 2.19 (s, 6H); ^{13}C NMR (C_6D_6 , 100MHz) δ (ppm) 149.0, 147.5, 142.6, 142.2, 139.1, 138.9, 135.1, 132.6, 130.1, 130.7, 128.1, 127.9, 127.2, 126.5, 125.9, 125.0, 124.5, 123.6, 121.8, 121.1, 119.2, 111.8, 110.8, 21.5.

[0125] Compound 9 was diluted in CHCl_3 to a concentration of 0.2 mM and a UV Spectrum of the diluted Compound 9 was obtained. Maximum absorption wavelengths were 358, 309 and 253 nm.

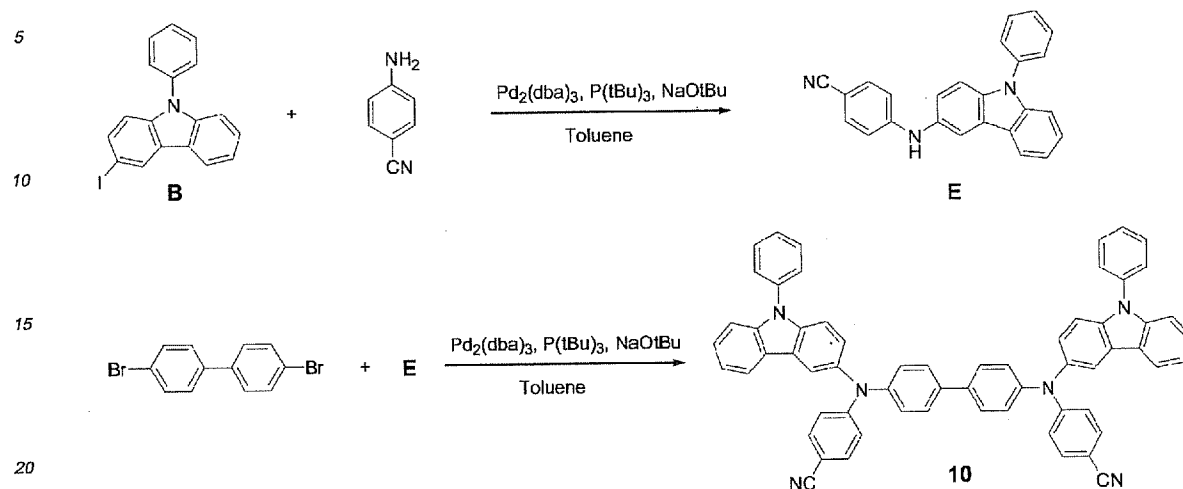
[0126] Td and Tg of Compound 9 were measured by performing thermal analysis using TGA and DSC under the following conditions: N_2 atmosphere, temperatures of room temperature to 600°C (10°C/min)-TGA and of room temperature to 400°C-DSC, and Pan Type: Pt Pan in disposable Al Pan (TGA) and disposable Al pan (DSC). The measured Td was 480°C and Tg was 155°C.

[0127] A HOMO level of 5.0 eV and a LUMO level of 2.02 eV were obtained using AC-2 that measures UV absorption spectrum and ionization potential.

Synthesis Example 3: Synthesis Compound 10

[0128] Compound 10 was synthesized through Reaction Scheme 4 below.

Reaction Scheme 4

Synthesis of Intermediate E

25 **[0129]** 3.69 g (10 mmol) of Intermediate B, 1.42 g (12 mmol) of 4-aminobenzonitril, 1.44 g (15 mmol) of t-BuONa, 183 mg (0.2 mmol) of $\text{Pd}_2(\text{dba})_3$, and 40 mg (0.2 mmol) of $\text{P}(\text{t-Bu})_3$ were dissolved in 50 ml of toluene and the mixture was stirred at 90°C for 3 hours.

30 **[0130]** After the reaction terminated, the resultant mixture was cooled to room temperature, and the resultant solution was extracted three times with distilled water and 50 ml of diethylether. An organic layer collected from the mixture was dried over MgSO_4 to evaporate the solvent. As a result, the dried result was purified using a silica gel column chromatography to produce 1.8 g of Intermediate E (Yield 50%).

Synthesis of Compound 10

35 **[0131]** 2.2 g (Yield 86%) of Compound 10 as a yellow solid was produced in the same manner as in Synthesis Example 1, except that Intermediate E and 4,4'-dibromodiphenyl were used instead of Intermediates B and C in the synthesis of Compound 8 of Synthesis Example 1.

40 **[0132]** ^1H NMR (CDCl_3 , 300MHz) δ (ppm) 8.02 (d, 2H), 7.97 (d, 2H), 7.64-7.48 (m, 14H), 7.43-7.39 (m, 10H), 7.29-7.22 (m, 8H), 7.03 (d, 4H); ^{13}C NMR (CDCl_3 , 100MHz) δ (ppm) 152.1, 145.6, 141.5, 138.9, 138.2, 137.3, 136.3, 133.2, 130.0, 127.9, 127.8, 127.0, 126.6, 125.8, 125.5, 124.6, 122.7, 120.5, 120.2, 119.9, 119.4, 118.9, 111.2, 110.1, 101.8.

[0133] Compound 10 was diluted in CHCl_3 to a concentration of 0.2 mM and a UV Spectrum of the diluted Compound 10 was obtained. Maximum absorption wavelengths were 304 and 238 nm.

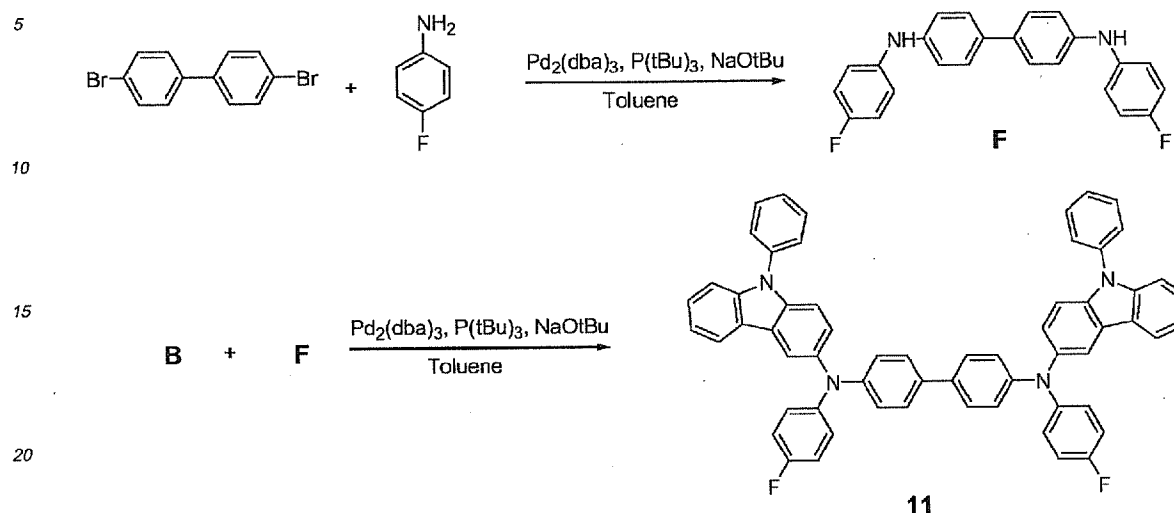
45 **[0134]** Td, Tg and Tm of Compound 10 were measured by performing thermal analysis using TGA and DSC under the following conditions: N_2 atmosphere, temperatures of room temperature to 600°C (10°C/min)-TGA and of room temperature to 400°C-DSC, and Pan Type: Pt Pan in disposable Al Pan (TGA) and disposable Al pan (DSC). The measured Td was 492°C, Tg was 178°C, and Tm was 263°C.

[0135] A HOMO level of 5.4 eV and a LUMO level of 2.47 eV were obtained using AC-2 that measures UV absorption spectrum and ionization potential.

50 Synthesis Example 4: Synthesis Compound 11

[0136] Compound 11 was synthesized through Reaction Scheme 5 below.

Reaction Scheme 5



25 **[0137]** Intermediate F was synthesized with a yield of 95% in the same manner as in Synthesis Example 1, except that 4-fluorophenylamine was used instead of aniline in the synthesis of Intermediate C of Synthesis Example 1. Then, 1.8 g (Yield 84%) of Compound 11 as a yellow solid was produced in the same manner as in Synthesis Example 1, except that Intermediate F was used instead of Intermediate C in the synthesis of Compound 8 of Synthesis Example 1.

30 **[0138]** ^1H NMR (C_6D_6 , 300MHz) δ (ppm) 8.05 (s, 2H), 7.68 (d, 2H), 7.48 (d, 4H), 7.29-7.11 (m, 22H), 7.09-7.01 (m, 6H), 6.78 (t, 4H)

[0139] Compound 11 was diluted in CHCl_3 to a concentration of 0.2 mM and UV Spectrum of the diluted Compound 11 was obtained. Maximum absorption wavelengths were 351, 297 and 248 nm.

35 **[0140]** Td, Tg, and Tm of Compound 11 were measured by performing thermal analysis using TGA and DSC under the following conditions: N_2 atmosphere, temperatures of room temperature to 600°C (10°C/min)-TGA and of room temperature to 400°C-DSC, and Pan Type: Pt Pan in disposable Al Pan (TGA) and disposable Al pan (DSC). The measured Td was 464°C, Tg was 151°C, and Tm was 299°C.

[0141] A HOMO level of 5.1 eV and a LUMO level of 2.28 eV were obtained using AC-2 that measures UV absorption spectrum and ionization potential.

40 Synthesis Example 5: Synthesis Compound 14

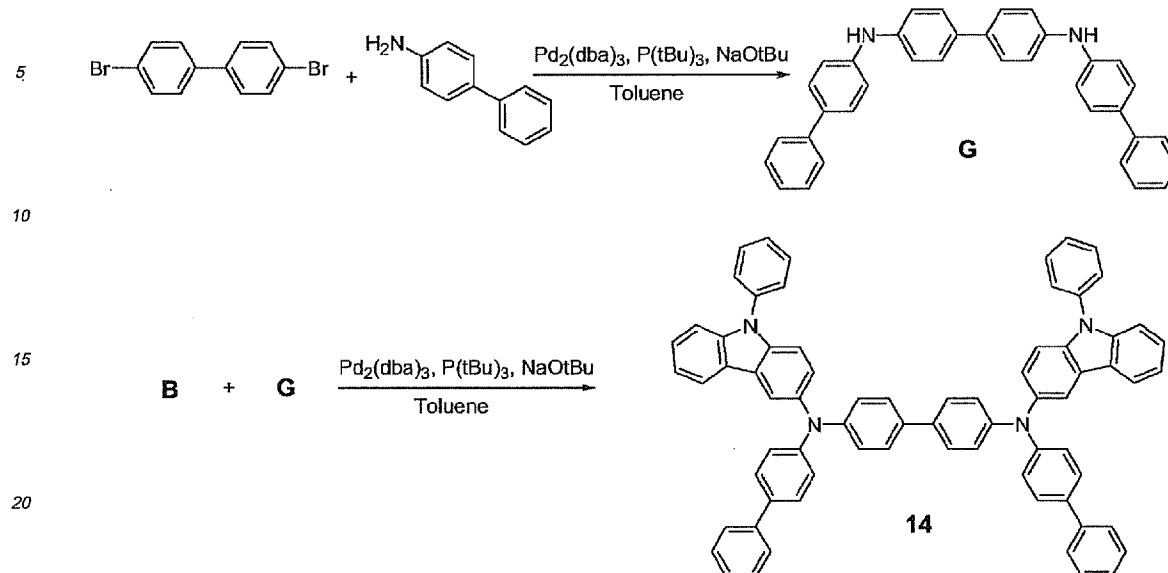
[0142] Compound 14 was synthesized through Reaction Scheme 6 below.

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Reaction Scheme 6



[0143] Intermediate G was synthesized with a yield of 90% in the same manner as in Synthesis Example 1, except that 4-aminobiphenyl was used instead of aniline in the synthesis of Intermediate C of Synthesis Example 1. Then, 3.1 g (Yield 82%) of Compound 14 as a yellow solid was produced in the same manner as in Synthesis Example 1, except that Intermediate G was used instead of Intermediate C in the synthesis of Compound 8 of Synthesis Example 1.

[0144] ^1H NMR (CD_2Cl_2 , 300MHz) δ (ppm) 8.02-8.01 (m, 4H), 7.65-7.56 (m, 12H), 7.51-7.46 (m, 10H), 7.43-7.36 (m, 10H), 7.32-7.17 (m, 14H), ^{13}C NMR (CD_2Cl_2 , 100MHz) δ (ppm) 148.2, 147.6, 141.8, 141.0, 140.6, 138.6, 137.9, 134.5, 134.4, 130.3, 129.1, 127.9, 127.8, 127.4, 127.3, 127.0, 126.8, 126.6, 126.1, 124.7, 123.5, 123.4, 123.0, 120.8, 120.3, 119.0, 111.1, 110.3.

[0145] Compound 14 was diluted in CHCl_3 to a concentration of 0.2 mM and a UV Spectrum of the diluted Compound 14 was obtained. Maximum absorption wavelength was 329 nm.

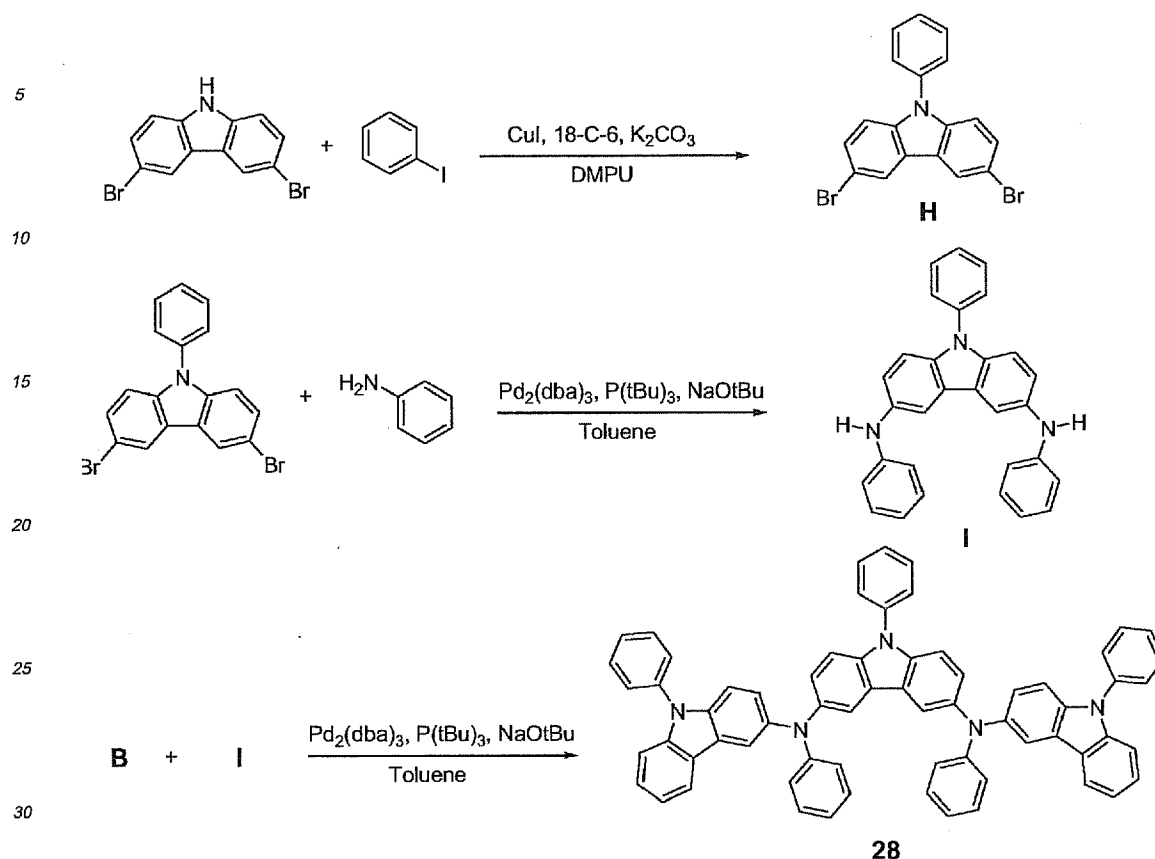
[0146] Td and Tg of Compound 14 were measured by performing thermal analysis using TGA and DSC under the following conditions: N_2 atmosphere, temperatures of room temperature to 600°C (10°C/min)-TGA and of room temperature to 400°C-DSC, and Pan Type: Pt Pan in disposable Al Pan (TGA) and disposable Al pan (DSC). The measured Td was 533°C and Tg was 174°C.

[0147] A HOMO level of 5.2 eV and a LUMO level of 2.27 eV were obtained using AC-2 that measures UV absorption spectrum and ionization potential.

Synthesis Example 6: Synthesis Compound 28

[0148] Compound 28 was synthesized through Reaction Scheme 7 below.

Reaction Scheme 7



35 **[0149]** Intermediate H was synthesized with a yield of 80% in the same manner as in Synthesis Example 1, except that 3,6-dibromocarbazole was used instead of carbazole in the synthesis of Intermediate A of Synthesis Example 1. Then, Intermediate I was synthesized with a yield of 85% in the same manner as in Synthesis Example 1, except that Intermediate H was used instead of 4,4'-dibromodiphenyl in the synthesis of Intermediate C of Synthesis Example 1. Then, 2.3 g (Yield 81 %) of Compound 28 as a yellow solid powder was produced in the same manner as in Synthesis Example 1, except that Intermediates B and I were used instead of Intermediates B and C in the synthesis of Compound 8 of Synthesis Example 1.

40 **[0150]** ^1H NMR (C_6D_6 , 300MHz) δ (ppm) 8.13 (s, 2H), 8.04 (s, 2H), 7.65 (d, 2H), 7.39-7.31 (m, 4H), 7.27-7.22 (m, 12H), 7.19-6.99 (m, 21H), 6.82 (t, 2H); ^{13}C NMR (C_6D_6 , 100MHz) δ (ppm) 150.4, 142.1, 141.9, 141.8, 138.8, 138.2, 138.0, 130.0, 129.9, 129.4, 128.3, 128.0, 127.8, 127.7, 127.3, 127.2, 127.1, 126.4, 126.3, 125.2, 125.1, 125.0, 123.8, 121.0, 120.7, 120.4, 120.2, 119.0, 117.7, 111.2, 110.9, 109.9.

45 **[0151]** Compound 28 was diluted in CHCl_3 to a concentration of 0.2 mM and UV Spectrum of the diluted Compound 28 was obtained. Maximum absorption wavelengths were 315 and 248 nm.

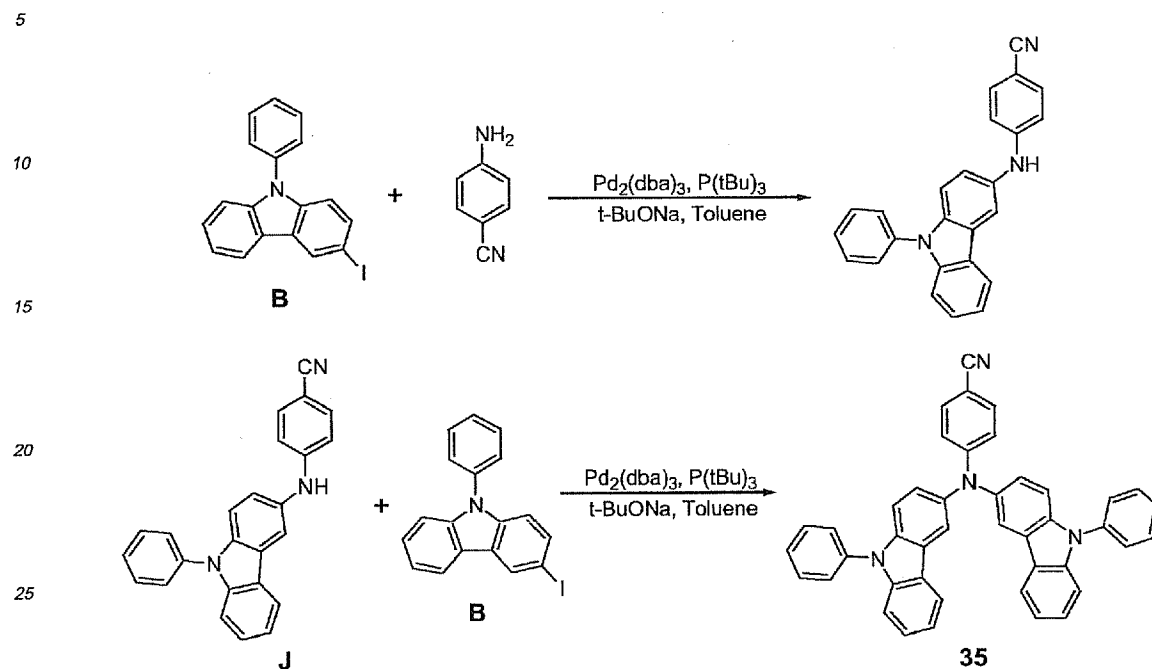
50 **[0152]** Td and Tg of Compound 28 were measured by performing thermal analysis using TGA and DSC under the following conditions: N_2 atmosphere, temperatures of room temperature to 600°C (10°C/min)-TGA and of room temperature to 400°C-DSC, and Pan Type: Pt Pan in disposable Al Pan (TGA) and disposable Al pan (DSC). The measured Td was 460°C and Tg was 175°C.

[0153] A HOMO level of 5.0 eV and a LUMO level of 2.09 eV were obtained using AC-2 that measures UV absorption spectrum and ionization potential.

55 Synthesis Example 7: Synthesis Compound 35

[0154] Compound 35 was synthesized through Reaction Scheme 8 below.

Reaction Scheme 8

Synthesis of Intermediate J

[0155] 0.316 g (0.856 mmol) of Intermediate B, 0.142 g (1.2 mmol) of 4-aminobenzonitril were dissolved in 5 ml of toluene and 0.144 g (1.5 mmol) of t-BuONa, 0.018 g (0.02 mmol) of $\text{Pd}(\text{dba})_2$, and 0.004 to 0.006 g (0.02 to 0.03 mmol) of $(\text{t-Bu})_3\text{P}$ were added thereto. The mixture was stirred at 80°C for 5 hours. The resultant solution was extracted three times with 20 ml of ethylether. An organic layer collected from the mixture was dried over MgSO_4 to evaporate the solvent. As a result, the dried result was purified using a silica gel column chromatography to produce 0.218 g of Intermediate J (Yield 71 %).

Synthesis of Compound 35

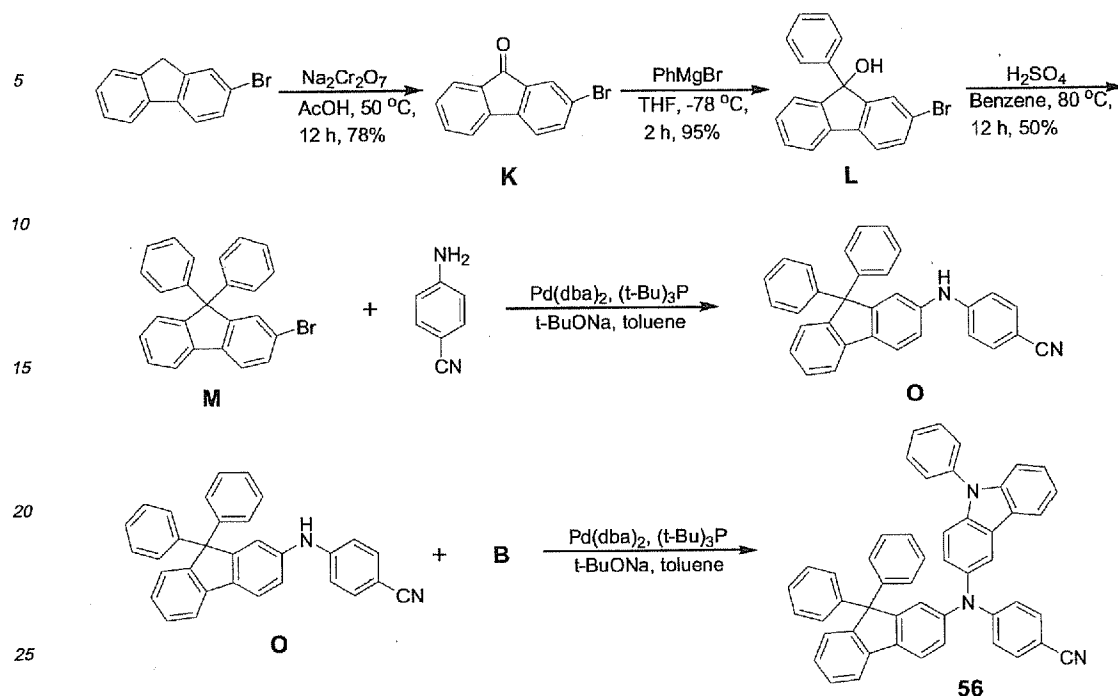
[0156] 0.221 g (0.614 mmol) of Intermediate J, 0.332 g (0.9 mmol) of Intermediate B were dissolved in 10 ml of toluene and 0.144 g (1.5 mmol) of t-BuONa, 0.018 g (0.02 mmol) of $\text{Pd}(\text{dba})_2$, and 0.004 to 0.006 g (0.02 to 0.03 mmol) of $(\text{t-Bu})_3\text{P}$ were added thereto. The mixture was stirred at 90°C for 6 hours. The resultant solution was extracted three times with 30 ml of ethylether. An organic layer collected from the mixture was dried over MgSO_4 to evaporate the solvent. As a result, the dried result was purified using a silica gel column chromatography to produce 0.236 g of Compound 35 (Yield 64%). Compound 35 was identified by $^1\text{H-NMR}$.

[0157] $^1\text{H-NMR}$ (CDCl_3 , 400MHz) δ (ppm) 8.05 (d, 2H), 8.03 (dd, 2H), 7.58 (m, 8H), 7.47 (m, 2H), 7.39 (m, 8H), 7.33 (dd, 2H), 7.24 (m, 2H), 6.94 (d, 2H).

Synthesis Example 8: Synthesis Compound 56

[0158] Compound 56 was synthesized through Reaction Scheme 9 below.

Reaction Scheme 9



Synthesis of Intermediate K

[0159] 13 g (53 mmol) of 2-bromofluorene was dissolved in 60 ml of acetic acid. The reaction mixture was set 0°C , and 60 g (200 mmol) of sodium dichromate was gradually added thereto. After 12 hours, 200 ml of distilled water was added thereto and the reaction mixture was sufficiently stirred. The produced yellow solid was filtered and dried to produce 10 g of Intermediate K (Yield 78%).

Synthesis of Intermediate L

[0160] 8 g (31.6 mmol) of Intermediate K was dissolved in 60 ml of THF. The temperature of the reaction mixture was set to -78°C , and 38 ml (38 mmol) of 1 M phenylmagnesium bromide was gradually added thereto. After 2 hours, the temperature was set to room temperature and stirred for 5 hours. The reaction mixture was diluted in 50 ml of ammonium chloride solution and extracted three times with 40 ml of ethylacetate. An organic layer collected from the mixture was dried over MgSO_4 to evaporate the solvent. As a result, the dried result was purified using a silica gel column chromatography to produce 10 g of Intermediate L (Yield 95%). Intermediate L was identified by $^1\text{H-NMR}$

[0161] $^1\text{H NMR}$ (CDCl_3 , 400MHz) δ (ppm) 7.64 (d, 1 H), 7.54-7.47 (m, 2H), 7.44 (d, 1 H), 7.39-7.33 (m, 3H), 7.30-7.23 (m, 5H), 2.46 (s, 1 H)

Synthesis of Intermediate M

[0162] 10 g (30 mmol) of Intermediate L was dissolved in 60 ml of benzene. 2.4 ml (45 mmol) of sulfuric acid diluted in a small amount of benzene was added thereto. The reaction mixture was stirred at 80°C for 5 hours. After the benzene was evaporated, 1 N NaOH was added to the reaction solution to adjust the pH of the reaction solution to 7. Then, the resultant solution was extracted three times with 40 ml of ethylacetate. An organic layer collected from the mixture was dried over MgSO_4 to evaporate the solvent. As a result, the dried result was purified using a silica gel column chromatography to produce 6 g of Intermediate M (Yield 50%).

Synthesis of Intermediate O

[0163] 340 mg (0.856 mmol) of Intermediate M, 142 mg (1.2 mmol) of 4-aminobenzonitril were dissolved in 5 ml of

toluene and 0.144 g (1.5 mmol) of t-BuONa, 0.018 g (0.02 mmol) of Pd(dba)₂, and 0.004 to 0.006 g (0.02 to 0.03 mmol) of (t-Bu)₃P were added thereto. The mixture was stirred at 80°C for 5 hours. The resultant solution was extracted three times with 20 ml of ethylether. An organic layer collected from the mixture was dried over MgSO₄ to evaporate the solvent. As a result, the dried result was purified using a silica gel column chromatography to produce 0.27 g of Intermediate O (Yield 73%).

Synthesis of Compound 56

[0164] 267 mg (0.614 mmol) of Intermediate O, 0.332 g (0.9 mmol) of Intermediate B (refer to Synthesis Example 1) were dissolved in 10 ml of toluene and 0.144 g (1.5 mmol) of t-BuONa, 0.018 g (0.02 mmol) of Pd(dba)₂, and 0.004 to 0.006 g (0.02 to 0.03 mmol) of (t-Bu)₃P were added thereto. The mixture was stirred at 90°C for 6 hours. The resultant solution was extracted three times with 30 ml of ethylether. An organic layer collected from the mixture was dried over MgSO₄ to evaporate the solvent. As a result, the dried result was purified using a silica gel column chromatography to produce 0.236 g of Compound 56 (Yield 57%). Compound 56 was identified by ¹H-NMR.

[0165] ¹H NMR (CDCl₃, 400MHz) δ (ppm) 7.97 (d, 1 H), 7.90 (d, 1H), 7.69 (d, 1 H), 7.65 (d, 1 H), 7.60 (d, 2H), 7.56 (dd, 2H), 7.48 (m, 1 H), 7.40 (d, 2H), 7.35 (m, 6H), 7.24 (m, 3H), 7.16 (m, 10H), 7.11 (dd, 1 H), 6.93 (d, 2H)

Example 1

[0166] An aluminium and ITO glass (SDI Co., Ltd.) substrate (1,300 Å) was cut into pieces of 50 mm x 50 mm x 0.7 mm in size, followed by ultrasonic cleaning in isopropyl alcohol and deionized water (5 minutes for each) and then UV/ozone cleaned (30 minutes) to produce a reflective electrode.

[0167] Then, Compound 8 was deposited on the reflective electrode to form a HIL with a thickness of 1,200 Å, and NPB was deposited on the HIL to form a HTL with a thickness of 300 Å.

[0168] IDE 140 (Idemitsu Corporation) as a blue fluorescent host and IDE 105 (Idemitsu Corporation) as a blue fluorescent dopant were deposited at the same time in a weight ratio of 98:2 on the HTL to form a blue EML with a thickness of 300 Å. Then, Balq was deposited on the blue EML to form a HBL with a thickness of 50 Å. Alq₃ was deposited on the HBL to form an ETL with a thickness of 250 Å. LiF was deposited on the ETL to form an EIL with a thickness of 3 Å, and then Mg:Ag was deposited on the EIL to form a semitransparent electrode with a thickness of 180 Å. As a result, an organic light emitting device was manufactured.

[0169] At a driving voltage of 5.5 V, the current density of the organic light emitting device was 23.0 mA/cm², the luminance was 1,179 cd/m², the color coordinates were (0.113, 0.130), and the light emitting efficiency was 5.13 cd/A.

Example 2

[0170] An organic light emitting device was manufactured in the same manner as in Example 1 except that Compound 9 was used instead of Compound 8 in the formation of a HIL.

[0171] At a driving voltage of 5.5 V, the current density of the organic light emitting device was 20.1 mA/cm², the luminance was 1,021 cd/m², the color coordinates were (0.113, 0.120), and the light emitting efficiency was 5.10 cd/A.

Example 3

[0172] An organic light emitting device was manufactured in the same manner as in Example 1 except that IDE 406 (Idemitsu Corporation) was used instead of Compound 8 in the formation of a HIL.

[0173] At a driving voltage of 5.5 V, the current density of the organic light emitting device was 46.52 mA/cm², the luminance was 784 cd/m², the color coordinates were (0.113, 0.125), and the light emitting efficiency was 4.74 cd/A.

Example 4

[0174] An organic light emitting device was manufactured in the same manner as in Example 1 except that Li273 (Sensient, Germany) was used instead of Compound 8 in the formation of a HIL.

[0175] At a driving voltage of 5.5 V, the current density of the organic light emitting device was 17.43 mA/cm², the luminance was 695 cd/m², the color coordinates were (0.122, 0.110), and the light emitting efficiency was 3.98 cd/A.

Example 5

[0176] An organic light emitting device was manufactured in the same manner as in Example 1 except that HI102 (UDC, U.S.A.) was used instead of Compound 8 in the formation of a HIL.

[0177] At a driving voltage of 5.5 V, the current density of the organic light emitting device was 0.67 mA/cm², the luminance was 1.2 cd/m², the color coordinates were (0.112, 0.154), and the light emitting efficiency was 0.18 cd/A.

Example 6

[0178] An organic light emitting device was manufactured in the same manner as in Example 1 except that ELM180 (ELM, Korea) was used instead of Compound 8 in the formation of a HIL.

[0179] At a driving voltage of 5.5 V, the current density of the organic light emitting device was 2.55 mA/cm², the brightness was 52 cd/m², the color coordinates were (0.124, 0.105), and the light emitting efficiency was 2.04 cd/A.

[0180] Referring to Examples 1 through 6, when Compound 8 or 9 was used to form the HIL or the thickness of the HIL was controlled according to an embodiment of the present invention, the hole injecting capability increased, and thus the current densities and the current efficiencies of the organic light emitting devices increased at the same driving voltage and luminance increased. The results of the current efficiencies at the same voltage are illustrated in FIG. 3.

[0181] The evaluation results for the luminance changes and driving voltage changes of the organic light emitting devices according to Examples 1 and 3 are shown in FIGS. 4 and 5. An accelerated life test was performed to measure luminance changes of the organic light emitting devices of Examples 1 and 3. The luminances were measured after 200 hours at 4,000 cd/m² as shown in FIG. 4. The luminance of the organic light emitting device of Example 1 after 200 hours at 4,000 cd/m² was 90.2% of the initial luminance, and the luminance of the organic light emitting device of Example 3 after 200 hours at 4,000 cd/m² was 86.2% of the initial luminance. FIG. 5 illustrates the accelerated life test results of the driving voltage changes after 400 hours at 4,000 cd/m². The driving voltage of the organic light emitting device of Example 1 increased by 0.45 V and the driving voltage of the organic light emitting device of Example 3 increased by 1.65 V. Referring to FIG. 5, the organic light emitting device of Example 1 has low power consumption and low driving voltage.

Example 7

[0182] An organic light emitting device was manufactured in the same manner as in Example 1 except that Compound 11 was deposited on the electrode to form a HIL with a thickness of 1600 Å, and CBP and Ir(ppy)₃ as green light emitting materials were deposited on the HTL to form a green EML with a thickness of 300 Å instead of the blue EML.

[0183] At a driving voltage of 5 V, the current density of the organic light emitting device was 7.5 mA/cm², the luminance was 2220 cd/m², the color coordinates were (0.244, 0.71), and the light emitting efficiency was 29.6 cd/A.

Example 8

[0184] An organic light emitting device was manufactured in the same manner as in Example 7 except that IDE 406 (Idemitsu Corporation) was used instead of Compound 11 in the formation of a HIL.

[0185] At a driving voltage of 5 V, the current density of the organic light emitting device was 7.86 mA/cm², the luminance was 1,900 cd/m², the color coordinates were (0.246, 0.691), and the light emitting efficiency was 23.9 cd/A.

[0186] The current efficiencies of Examples 7 and 8 are shown in FIG. 6.

Example 9

[0187] An organic light emitting device was manufactured in the same manner as in Example 1 except that Compound 14 was deposited on the electrode to form a HIL with a thickness of 2000 Å, and CBP and BPTIr as red light emitting materials were deposited on the HTL to form a red EML with a thickness of 300 Å instead of the blue EML.

[0188] At a driving voltage of 5 V, the current density of the organic light emitting device was 11.8 mA/cm², the luminance was 1,534 cd/m², the color coordinates were (0.687, 0.310), and the light emitting efficiency was 13.0 cd/A.

Example 10

[0189] An organic light emitting device was manufactured in the same manner as in Example 9 except that IDE 406 (Idemitsu Corporation) was used instead of Compound 14 in the formation of a HIL.

[0190] At a driving voltage of 5 V, the current density of the organic light emitting device was 13.3 mA/cm², the brightness was 1328 cd/m², the color coordinates were (0.692, 0.306), and the light emitting efficiency was 9.98 cd/A.

[0191] The current efficiencies of Examples 9 and 10 are shown in FIG. 7.

[0192] The driving voltage, efficiency, and color purity characteristics of the organic light emitting devices of Examples 1-10 were evaluated using an IVL measuring device (PhotoResearch PR650, Keithley 238).

Example 11

[0193] An organic light emitting device including red, s green, and blue EMLs was manufactured as follows.

[0194] A substrate having a thin film transistor was prepared, and a first electrode composed of Al was formed in a stripe shape with a thickness of 1000 Å. Here, the first electrode was electrically connected to a source electrode or a drain electrode of the thin film transistor formed on the substrate.

[0195] Red, green and blue sub-pixel defining layers which define regions in which the red, green, and blue EMLs will be formed were formed on the first electrode using a silicon oxide. Compound 8 was deposited on the regions in which the red, green and blue EML will be formed to form a HIL. Compound 8 was deposited on the region in which the red EML will be formed to a thickness of 2000 Å, on the region in which the green EML will be formed a thickness of 1600 Å, and on the region in which the blue EML will be formed to a thickness of 1200 Å to form the HIL. Then, NPB was deposited on the HIL to form a HTL with a thickness of 300 Å.

[0196] CBP and BPTir as red light emitting materials were deposited on the HTL to form a red EML with a thickness of 300 Å, CBP and Irppy as green light emitting materials were deposited on the HTL to form a green EML with a thickness of 300 Å, and IDE 140 (Idemitsu Corporation) and IDE 105 (Idemitsu Corporation) as blue light emitting materials were deposited on the HTL to form a blue EML with a thickness of 150 Å.

[0197] Then, Balq was deposited on the red, green and blue EMLs to form a HBL with a thickness of 50 Å. Alq3 was deposited on the HBL to form an ETL with a thickness of 250 Å. LiF was deposited on the ETL to form an EIL with a thickness of 3 Å, and then Mg:Ag was deposited on the EIL to form a semitransparent electrode with a thickness of 180 Å. As a result, an organic light emitting device including the red, green, and blue EMLs was manufactured.

[0198] The efficiency and the color coordinates of the organic light emitting device of Example 11 were measured in the same manner as in Examples 1 through 10. The results are shown in Table 1.

Table 1

	Efficiency (cd/A)	x Color Coordinate	y Color Coordinate
Red EML	13.4	0.68	0.32
Green EML	29.9	0.22	0.73
Blue EML	2.9	0.14	0.06

[0199] As shown in Table 1, each EML of the organic light emitting device of Example 11 exhibited excellent efficiency and color purity. The efficiency of white light comprising a mixture of red, green, and blue light in the organic light emitting device of Example 11 was 13.0 cd/A at a luminance of 150 cd/m² when 40% of the device was operating, and power consumption was 180 mW. The efficiency and color purity characteristics of the organic light emitting device of Example 11 were evaluated using an IVL measuring device (PhotoResearch PR650, Keithley 238) and the power consumption was calculated.

Example 12

[0200] An organic light emitting device was manufactured in the same manner as in Example 11 except that IDE 406 (Idemitsu Corporation) was used instead of Compound 8 to form a HIL. The efficiency and the color coordinates of the organic light emitting device of Example 12 are shown in Table 2.

Table 2

	Efficiency (cd/A)	x Color Coordinate	y Color Coordinate
Red EML	12.1	0.67	0.32
Green EML	25.4	0.23	0.73
Blue EML	2.24	0.14	0.06

[0201] As shown in Table 2, each EML of the organic light emitting device of Example 12 exhibited excellent efficiency and color purity. The efficiency of white light comprising a mixture of red, green, and blue light in the organic light emitting device of Example 12 was 11.0 cd/A at a brightness of 150 cd/m² when 40% of the device was operating, and power consumption was 220 mW. The efficiency and color purity characteristics of the organic light emitting device of Example 12 were evaluated using an IVL measuring device (PhotoResearch PR650, Keithley 238) and the power consumption

was calculated.

Comparative Example 1

5 [0202] A substrate having a thin film transistor was prepared, and a first electrode composed of Al was formed in a stripe shape with a thickness of 1000 Å. Here, the first electrode was electrically connected to a source electrode or a drain electrode of the thin film transistor formed on a lower portion of the substrate.

10 [0203] Red, green and blue pixel defining layers which define regions in which red, green, and blue emission layers will be formed were formed on the pixel electrode using a silicon oxide. M-TDATA was deposited on the regions in which red, green and blue emission layers will be formed from a HIL with a thickness of 1000 Å. Then NPB was deposited on the HIL to form a HTL with a thickness of 400 Å. In addition, NPB was further deposited over the region in which green EML will be formed to a thickness of 400 Å using a photomask. NPB was further deposited over the region in which red EML will be formed to a thickness of 800 Å. As a result, HTL having total thickness of 1200 Å in the region in which red EML will be formed, total thickness of 800 Å in the region in which green EML will be formed and total thickness of 400 Å in the region in which blue EML will be formed.

15 [0204] CBP and BPTIr as red light emitting materials were deposited on the red HTL to form a red EML with a thickness of 300 Å, CBP and Irppy as green light emitting materials were deposited on the green HTL to form a green EML with a thickness of 300 Å, and IDE 140 (Idemitsu Corporation) and IDE 105 (Idemitsu Corporation) as blue light emitting materials were deposited on the blue HTL to form a blue EML with a thickness of 150 Å.

20 [0205] Then, Balq was deposited on the red, green and blue EMLs to form a HBL with a thickness of 50 Å. Alq3 was deposited on the HBL to form an ETL with a thickness of 250 Å. LiF was deposited on the ETL to form an EIL with a thickness of 3 Å, and then Mg:Ag was deposited on the EIL to form a semitransparent electrode with a thickness of 180 Å. As a result, an organic light emitting device including the red, green, and blue EMLs was manufactured.

25 [0206] The efficiency and the color coordinates of the organic light emitting device of Comparative Example 1 are shown in Table 3.

Table 3

	Efficiency (cd/A)	x Color Coordinate	y Color Coordinate
Red EML	5.39	0.67	0.32
Green EML	24.45	0.21	0.72
Blue EML	1.40	0.14	0.06

30 [0207] As shown in Table 3, the organic light emitting device of Example 11 having a material used to form a HIL according to an embodiment of the present invention and the organic light emitting device of Example 12 having the thickness of the HIL according to an embodiment of the present invention exhibited greater efficiency and color purity than the organic light emitting device of Comparative Example 1.

35 [0208] An organic light emitting device according to the present invention includes an organic layer containing one of the compounds represented by Formulae 1, 2, and 3 between a pair of electrodes capable of generating resonance during the operation of the device; and/or a hole injection layer having the thickness range described above between the pair of electrodes. The organic light emitting device of the present invention has low driving voltage, excellent current density, high brightness, excellent color purity, high efficiency, and long lifetime. In particular, the organic light emitting device of the present invention has excellent lifetime property. A flat panel display device having enhanced reliability can be obtained by employing the organic light emitting device of the present invention.

Claims

50 1. An organic light emitting device comprising:

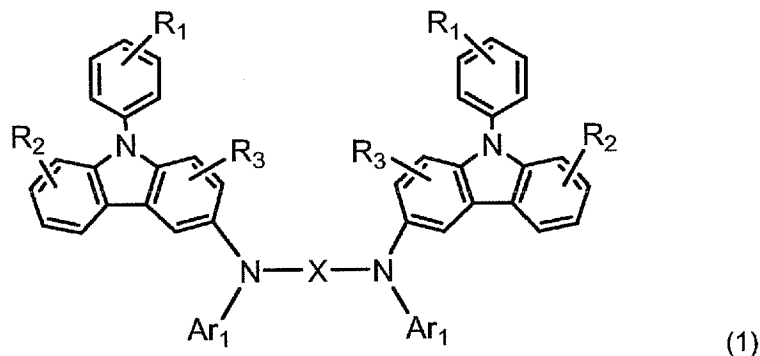
a substrate;

a first electrode;

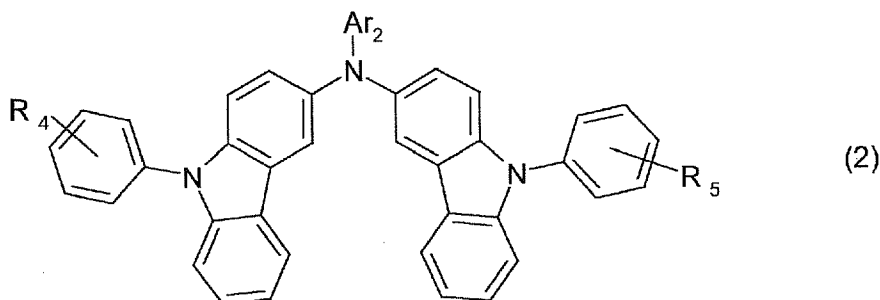
a second electrode facing the first electrode; and

55 an organic layer interposed between the first electrode and the second electrode, wherein resonance is occurring between the first electrode and the second electrode during the operation of the organic light emitting device and the organic layer comprises a compound selected from the group consisting of compounds represented

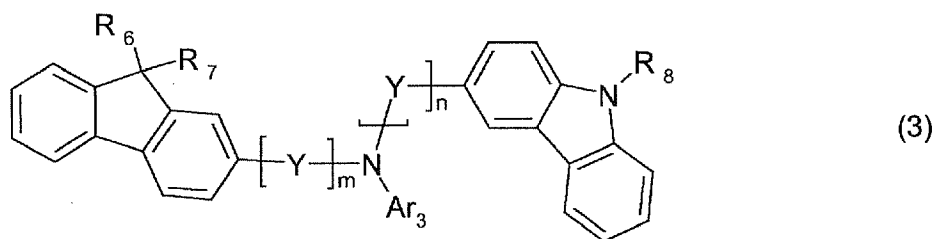
by any of formulae (1) to (3):



where X is selected from the group consisting of a substituted or unsubstituted C₁-C₃₀ alkylene group, a substituted or unsubstituted C₂-C₃₀ alkenylene group, a substituted or unsubstituted C₆-C₃₀ arylene group, a substituted or unsubstituted C₂-C₃₀ heteroarylene group, and a substituted or unsubstituted C₂-C₃₀ hetero ring, each R₁, each R₂ and each R₃ is independently selected from the group consisting of a hydrogen atom, a substituted or unsubstituted C₁-C₃₀ alkyl group, a substituted or unsubstituted C₁-C₃₀ alkoxy group, a substituted or unsubstituted C₆-C₃₀ aryl group, a substituted or unsubstituted C₆-C₃₀ aryloxy group, a substituted or unsubstituted C₂-C₃₀ hetero ring, a substituted or unsubstituted C₅-C₃₀ polycyclic condensed ring, a hydroxy group, a cyano group, and a substituted or unsubstituted amino group, wherein two or more of R₁, R₂ and R₃ can be optionally bound with one another to form a saturated or unsaturated carbon ring, and each Ar₁ is independently selected from the group consisting of substituted or unsubstituted C₆-C₃₀ aryl group and a substituted or unsubstituted C₂-C₃₀ heteroaryl group;



wherein R₄ and R₅ are independently selected from the group consisting of a hydrogen atom, a substituted or unsubstituted C₁-C₃₀ alkyl group, a substituted or unsubstituted C₁-C₃₀ alkoxy group, a substituted or unsubstituted C₆-C₃₀ aryl group, a substituted or unsubstituted C₆-C₃₀ aryloxy group, a substituted or unsubstituted C₂-C₃₀ hetero ring, a substituted or unsubstituted C₅-C₃₀ polycyclic condensed ring, a hydroxy group, a cyano group, and a substituted or unsubstituted amino group, wherein R₄ and R₅ can be optionally bound with one another to form a saturated or unsaturated carbon ring, and Ar₂ is a substituted or unsubstituted C₆-C₃₀ aryl group or a substituted or unsubstituted C₂-C₃₀ heteroaryl group; and



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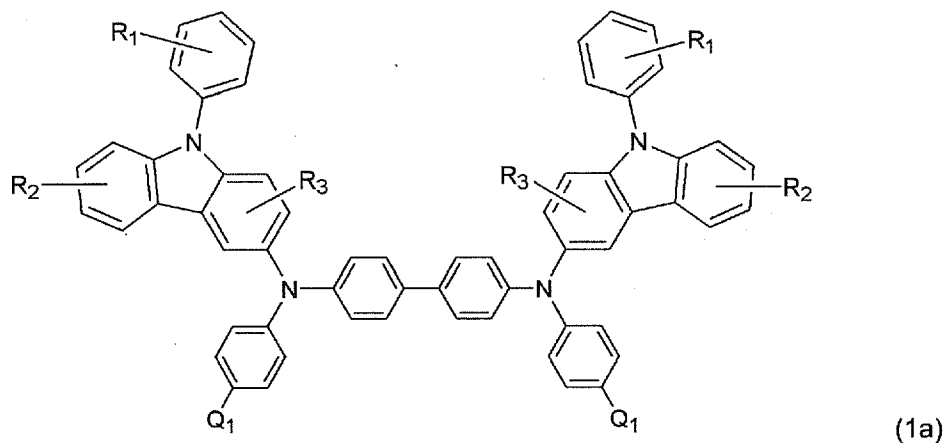
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wherein R_6 , R_7 and R_8 are independently selected from the group consisting of a hydrogen atom, a substituted or unsubstituted C_1 - C_{30} alkyl group, a substituted or unsubstituted C_1 - C_{30} alkoxy group, a substituted or unsubstituted C_6 - C_{30} aryl group, a substituted or unsubstituted C_6 - C_{30} aryloxy group, a substituted or unsubstituted C_2 - C_{30} hetero ring, a substituted or unsubstituted C_5 - C_{30} polycyclic condensed ring, a hydroxy group, a cyano group, and a substituted or unsubstituted amino group, wherein R_6 and R_7 can be optionally bound with one another to form a saturated or unsaturated carbon ring,

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Ar_3 is a substituted or unsubstituted C_6 - C_{30} aryl group or a substituted or unsubstituted C_2 - C_{30} heteroaryl group, each Y is selected independently from the group consisting of a substituted or unsubstituted C_1 - C_{30} alkyl group, a substituted or unsubstituted C_6 - C_{30} aryl group, and a substituted or unsubstituted C_2 - C_{30} hetero ring, and m and n are an integer from 0 to 5.

2. The organic light emitting device of claim 1, wherein in formula (1) R_1 to R_3 are hydrogen atoms.
- 25 3. The organic light emitting device of one of claims 1 or 2, wherein in formula (1) Ar_1 is a substituted or unsubstituted C_6 - C_{30} aryl group.
4. The organic light emitting device of one of claims 1 to 3, wherein in formula (1) X is selected from the group consisting of a substituted or unsubstituted C_6 - C_{30} arylene group and a substituted or unsubstituted C_2 - C_{30} heteroarylene group.
- 30 5. The organic light emitting device of claim 1, wherein the compound represented by formula (1) is a compound represented by formula (1 a):



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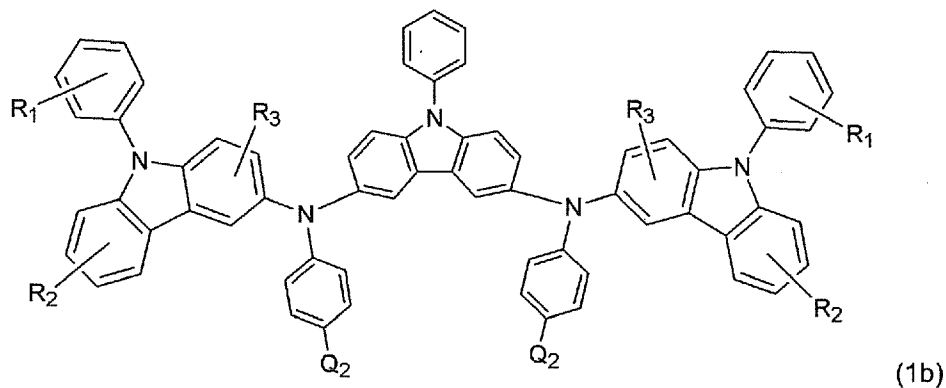
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where each R_1 , each R_2 , and each R_3 are each independently selected from the group consisting of a hydrogen atom, a substituted or unsubstituted C_1 - C_{30} alkyl group, a substituted or unsubstituted C_1 - C_{30} alkoxy group, a substituted or unsubstituted C_6 - C_{30} aryl group, a substituted or unsubstituted C_6 - C_{30} aryloxy group, a substituted or unsubstituted C_2 - C_{30} hetero ring, a substituted or unsubstituted C_5 - C_{30} polycyclic condensed ring, a hydroxy group, a cyano group, and a substituted or unsubstituted amino group, wherein two or more of R_1 , R_2 and R_3 can be optionally bound with one another to form a saturated or unsaturated carbon ring; and each Q_1 is independently selected from the group consisting of a hydrogen atom, a cyano group, a fluorine atom, a substituted or unsubstituted C_1 - C_{30} alkyl group, a substituted or unsubstituted C_6 - C_{30} aryl group, a substituted or

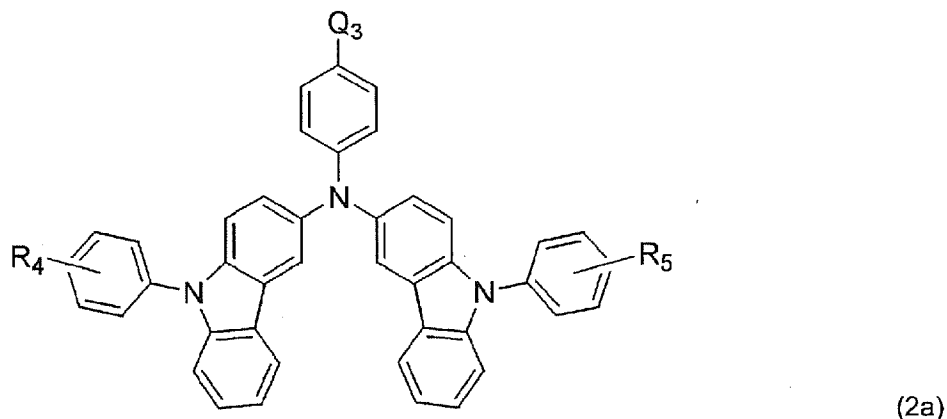
unsubstituted C₂-C₃₀ hetero ring, and a substituted or unsubstituted amino group.

6. The organic light emitting device of claim 1, wherein the compound represented by formula (1) is a compound represented by formula (1 b):



where each R₁, each R₂, and each R₃ are each independently selected from the group consisting of a hydrogen atom, a substituted or unsubstituted C₁-C₃₀ alkyl group, a substituted or unsubstituted C₁-C₃₀ alkoxy group, a substituted or unsubstituted C₆-C₃₀ aryl group, a substituted or unsubstituted C₆-C₃₀ aryloxy group, a substituted or unsubstituted C₂-C₃₀ hetero ring, a substituted or unsubstituted C₅-C₃₀ polycyclic condensed ring, a hydroxy group, a cyano group, and a substituted or unsubstituted amino group, wherein two or more of R₁, R₂ and R₃ can be optionally bound with one another to form a saturated or unsaturated carbon ring; and each Q₂ is independently selected from the group consisting of a hydrogen atom, a cyano group, a fluorine atom, a substituted or unsubstituted C₁-C₃₀ alkyl group, a substituted or unsubstituted C₆-C₃₀ aryl group, a substituted or unsubstituted C₂-C₃₀ hetero ring, and a substituted or unsubstituted amino group.

7. The organic light emitting device of claim 1, wherein in formula (2) R₄ and R₅ are hydrogen atoms.
8. The organic light emitting device of claim 1 or 7, wherein in formula (2) Ar₂ is a substituted or unsubstituted C₆-C₃₀ aryl group.
9. The organic light emitting device of claim 1, wherein the compound represented by formula (2) is a compound represented by formula (2a):

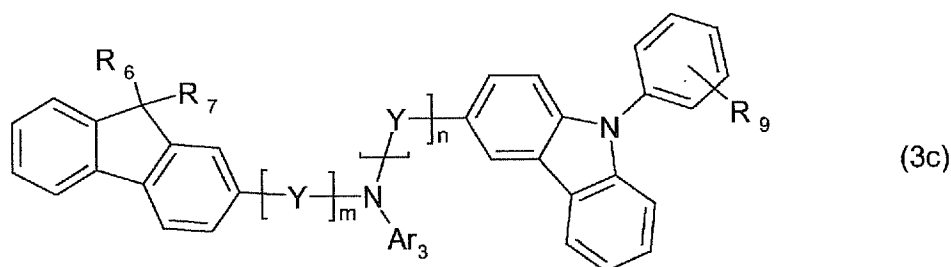


where R₄ and R₅ are each independently selected from the group consisting of a hydrogen atom, a substituted or unsubstituted C₁-C₃₀ alkyl group, a substituted or unsubstituted C₁-C₃₀ alkoxy group, a substituted or unsubstituted C₆-C₃₀ aryl group, a substituted or unsubstituted C₆-C₃₀ aryloxy group, a substituted or unsubstituted C₂-C₃₀ hetero

ring, a substituted or unsubstituted C₅-C₃₀ polycyclic condensed ring, a hydroxy group, a cyano group, and a substituted or unsubstituted amino group, wherein R₄ and R₅ can be optionally bound with one another to form a saturated or unsaturated carbon ring; and

Q₃ is selected from the group consisting of a hydrogen atom, a cyano group, a fluorine atom, a substituted or unsubstituted C₁-C₃₀ alkyl group, a substituted or unsubstituted C₆-C₃₀ aryl group, a substituted or unsubstituted C₂-C₃₀ hetero ring, and a substituted or unsubstituted amino group.

10. The organic light emitting device of claim 1, wherein the compound represented by formula (3) is a compound represented by formula (3c):



where R₉ is selected from the group consisting of a hydrogen atom, a substituted or unsubstituted C₁-C₃₀ alkyl group, a substituted or unsubstituted C₁-C₃₀ alkoxy group, a substituted or unsubstituted C₆-C₃₀ aryl group, a substituted or unsubstituted C₆-C₃₀ aryloxy group, a substituted or unsubstituted C₂-C₃₀ hetero ring, a substituted or unsubstituted C₅-C₃₀ polycyclic condensed ring, a hydroxy group, a cyano group, and a substituted or unsubstituted amino group.

11. The organic light emitting device of claim 1, wherein in formula (3) R₈ is a hydrogen atom.

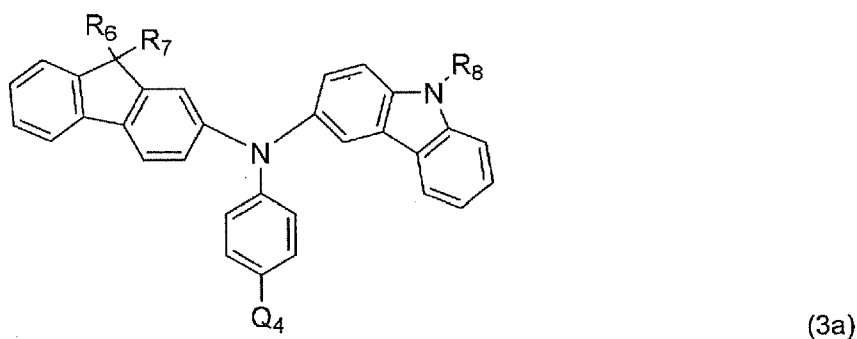
12. The organic light emitting device of claim 10, wherein in formula (3c) R₉ is a hydrogen atom.

13. The organic light emitting device of one of claim 1 and 10 to 12, wherein in formula (3) Ar₃ is a substituted or unsubstituted C₆-C₃₀ aryl group.

14. The organic light emitting device of one of claim 1 and 10 to 13, wherein in formula (3) R₆ and R₇ are each a methyl group or a phenyl group.

15. The organic light emitting device of one of claim 1 and 10 to 14, wherein in formula (3) m is 1, n is zero and Y is a phenyl group.

16. The organic light emitting device of claim 1, wherein the compound represented by formula (3) is a compound represented by formula (3a):

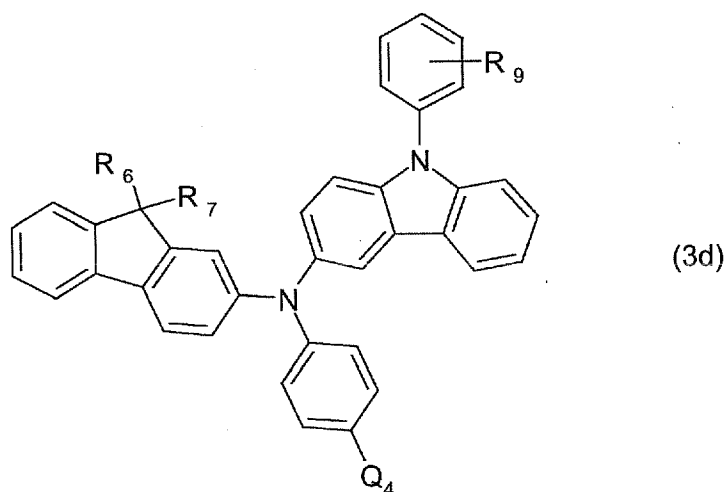


where R₆, R₇ and R₈ are each independently selected from the group consisting of a hydrogen atom, a substituted

or unsubstituted C₁-C₃₀ alkyl group, a substituted or unsubstituted C₁-C₃₀ alkoxy group, a substituted or unsubstituted C₆-C₃₀ aryl group, a substituted or unsubstituted C₆-C₃₀ aryloxy group, a substituted or unsubstituted C₂-C₃₀ hetero ring, a substituted or unsubstituted C₅-C₃₀ polycyclic condensed ring, a hydroxy group, a cyano group, and a substituted or unsubstituted amino group, wherein two or more of R₆, R₇ and R₈ can be optionally bound with one another to form a saturated or unsaturated carbon ring; and

Q₄ is selected from the group consisting of a hydrogen atom, a cyano group, a fluorine atom, a substituted or unsubstituted C₁-C₃₀ alkyl group, a substituted or unsubstituted C₆-C₃₀ aryl group, a substituted or unsubstituted C₂-C₃₀ hetero ring, and a substituted or unsubstituted amino group.

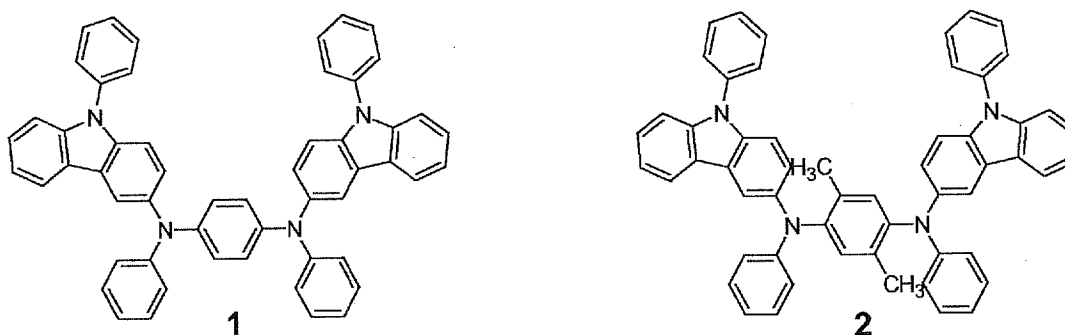
17. The organic light emitting device of claim 1, wherein the compound represented by formula (3) is a compound represented by formula (3d):

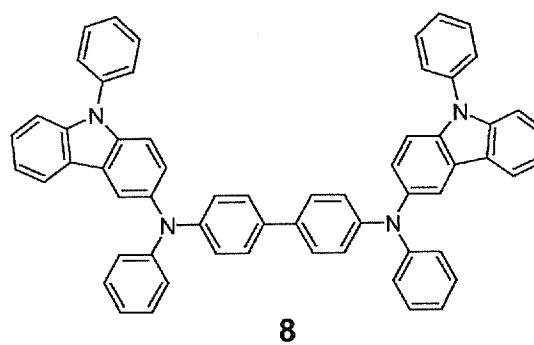
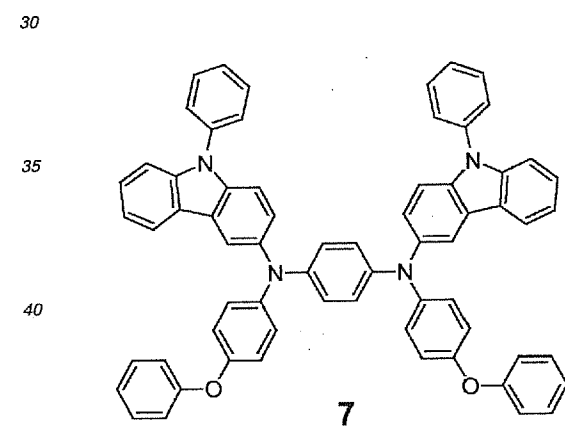
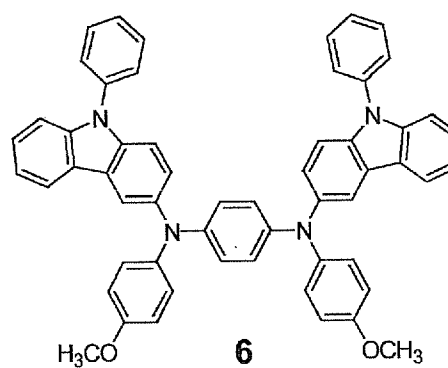
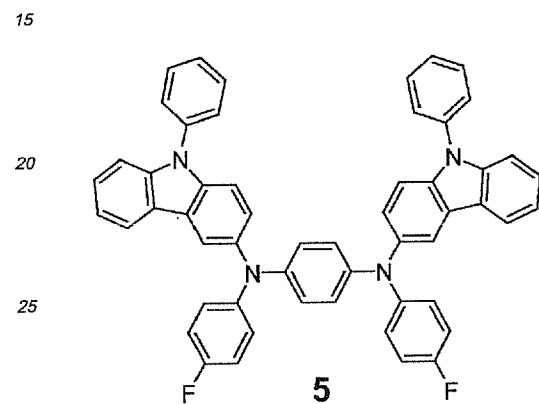
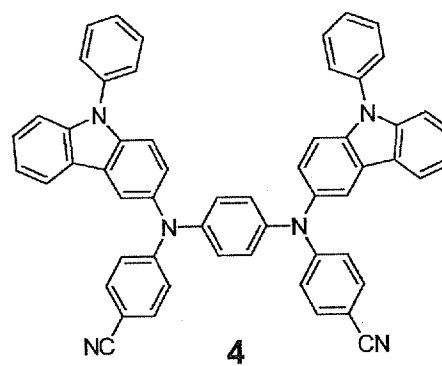
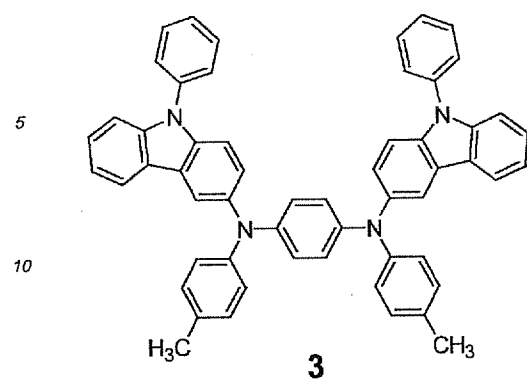


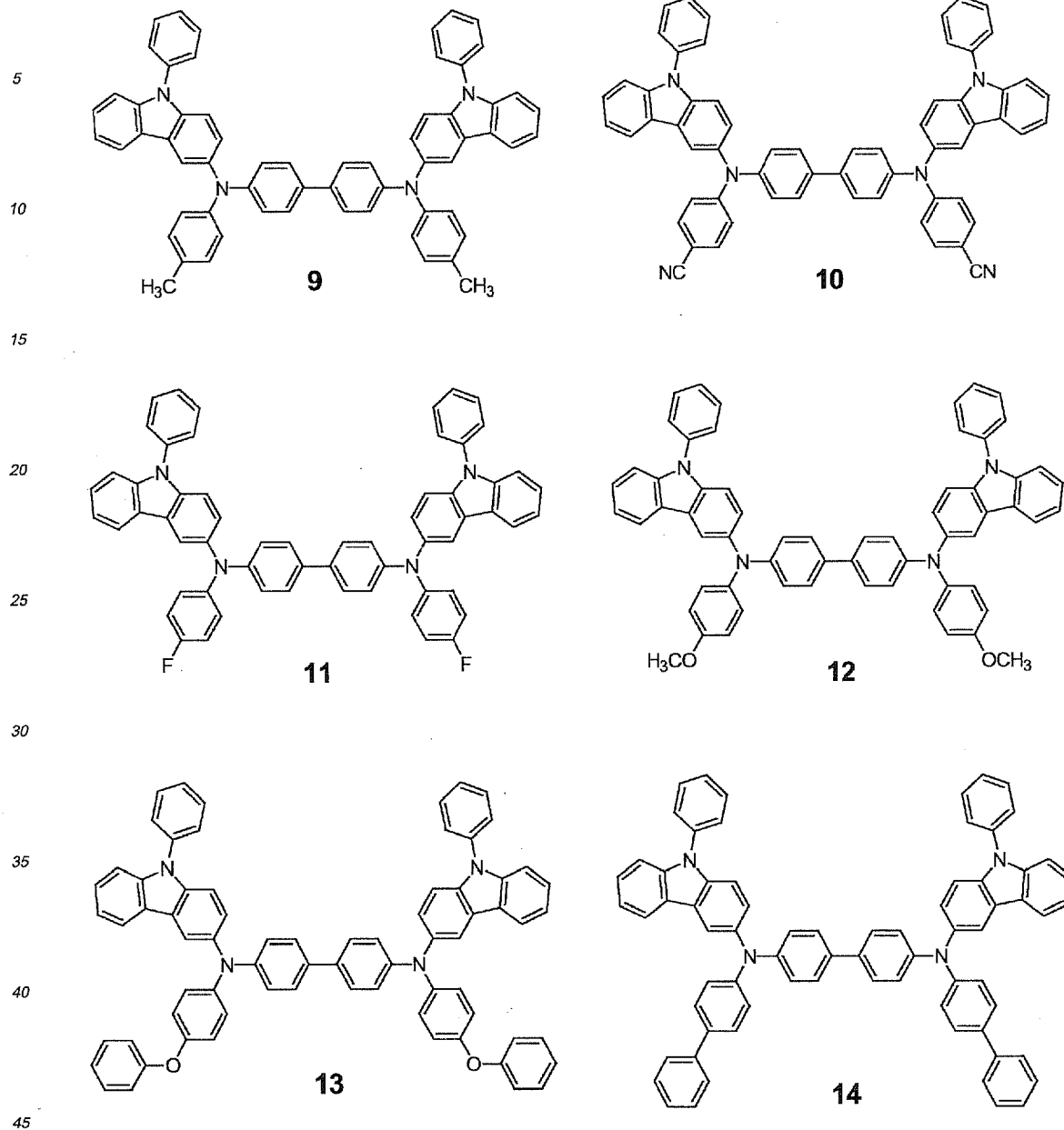
where R₆, R₇ and R₉ are each independently selected from the group consisting of a hydrogen atom, a substituted or unsubstituted C₁-C₃₀ alkyl group, a substituted or unsubstituted C₁-C₃₀ alkoxy group, a substituted or unsubstituted C₆-C₃₀ aryl group, a substituted or unsubstituted C₆-C₃₀ aryloxy group, a substituted or unsubstituted C₂-C₃₀ hetero ring, a substituted or unsubstituted C₅-C₃₀ polycyclic condensed ring, a hydroxy group, a cyano group, and a substituted or unsubstituted amino group, wherein two or more of R₆, R₇ and R₈ can be optionally bound with one another to form a saturated or unsaturated carbon ring; and

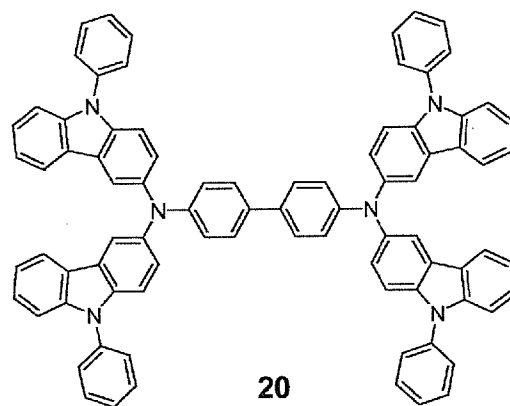
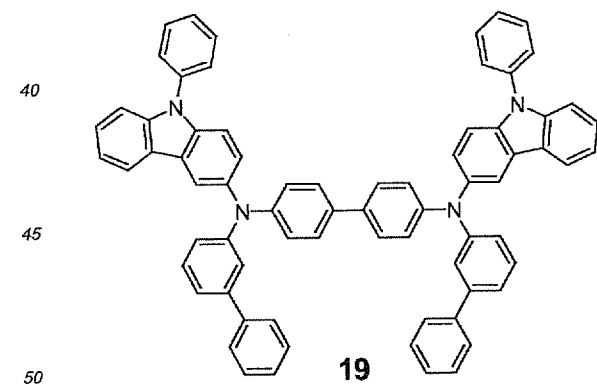
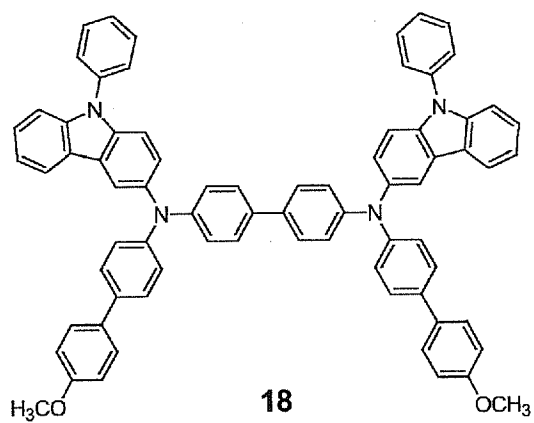
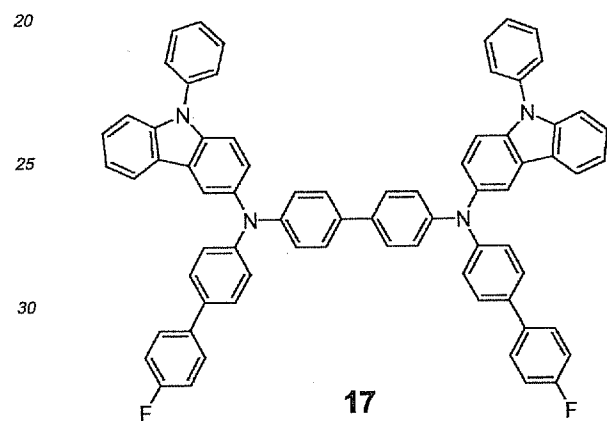
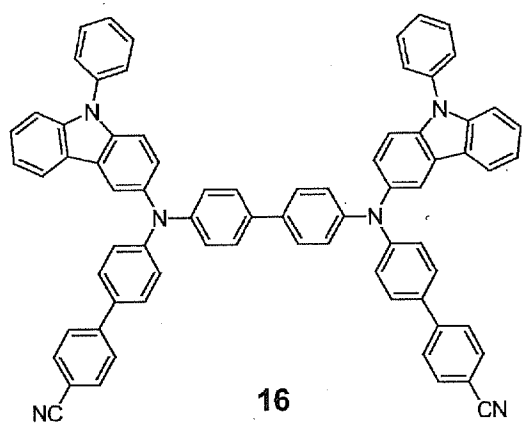
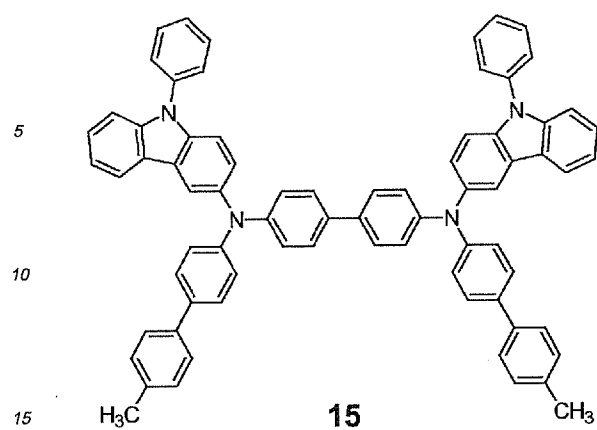
Q₄ is selected from the group consisting of a hydrogen atom, a cyano group, a fluorine atom, a substituted or unsubstituted C₁-C₃₀ alkyl group, a substituted or unsubstituted C₆-C₃₀ aryl group, a substituted or unsubstituted C₂-C₃₀ hetero ring, and a substituted or unsubstituted amino group.

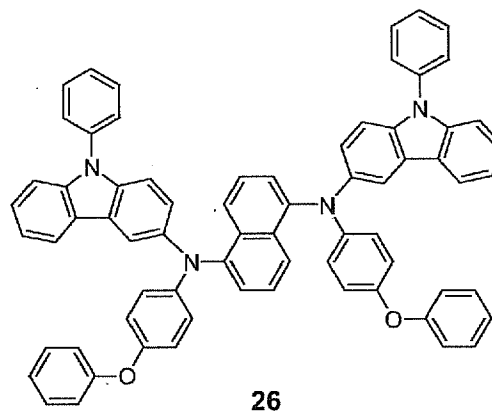
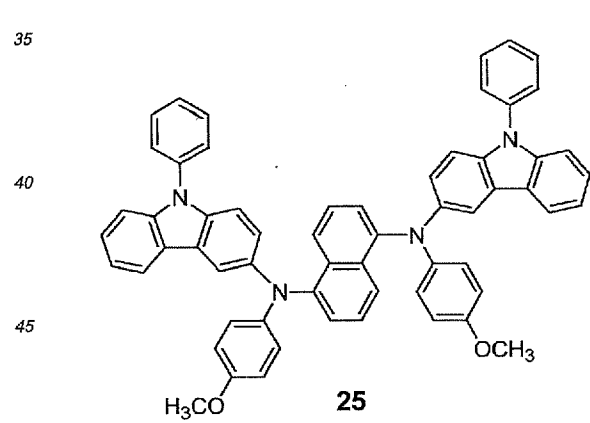
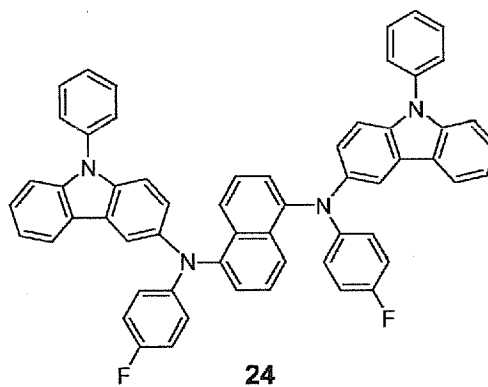
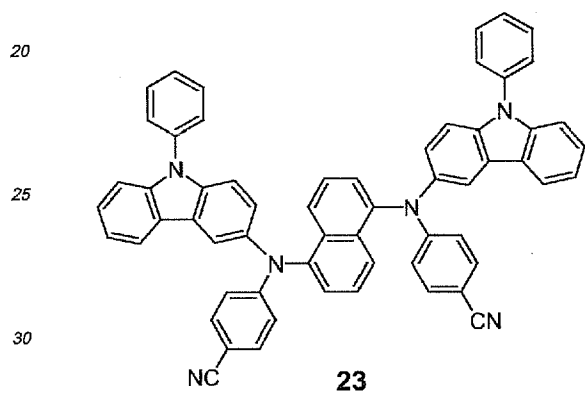
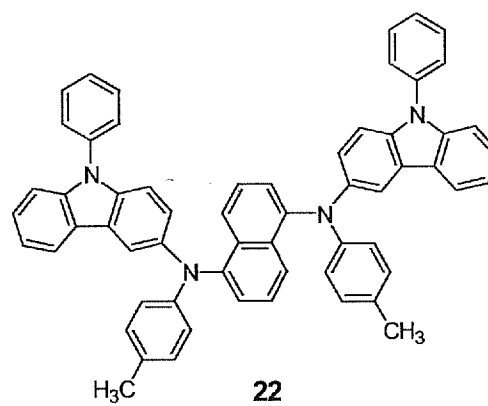
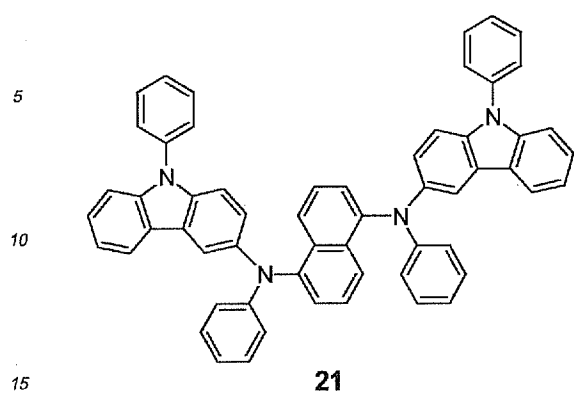
18. The organic light emitting device of claim 1, wherein the compounds represented by formulae (1), (2), and (3) are one of compounds 1 through 62:

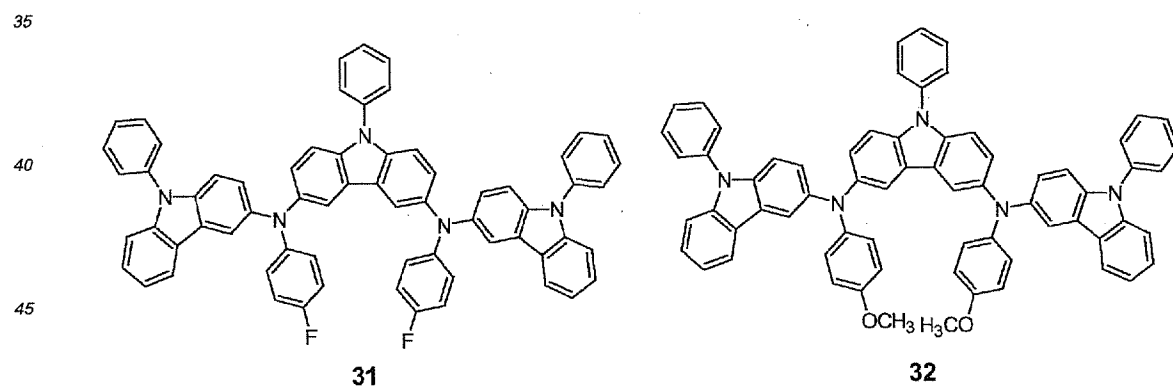
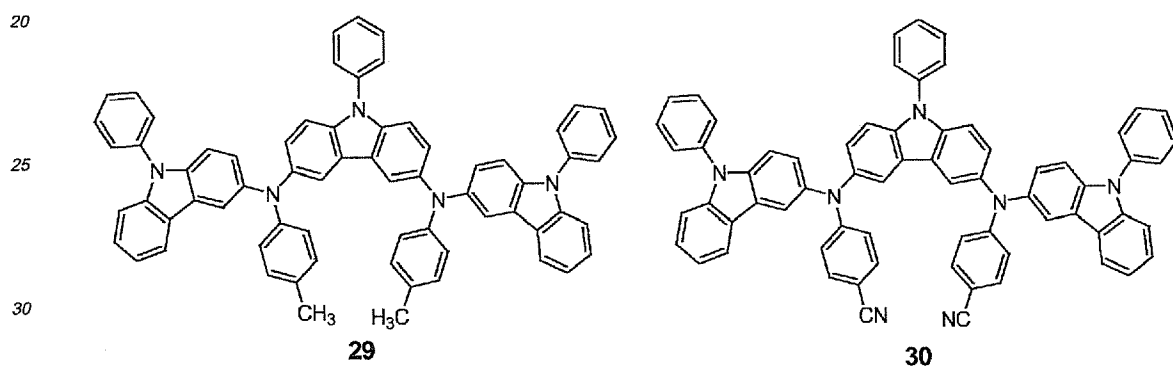
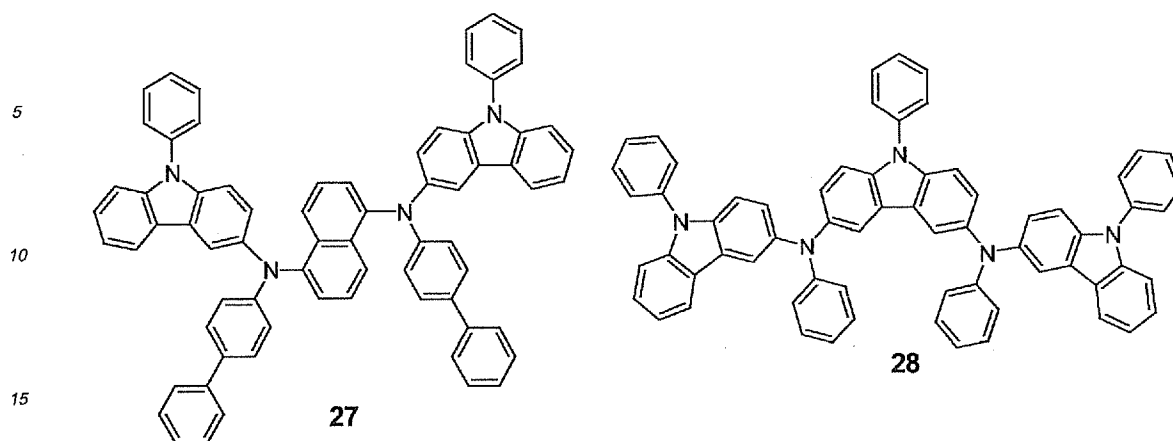






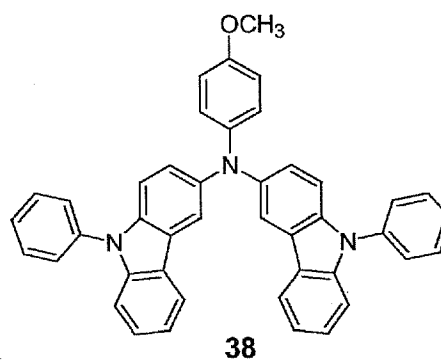
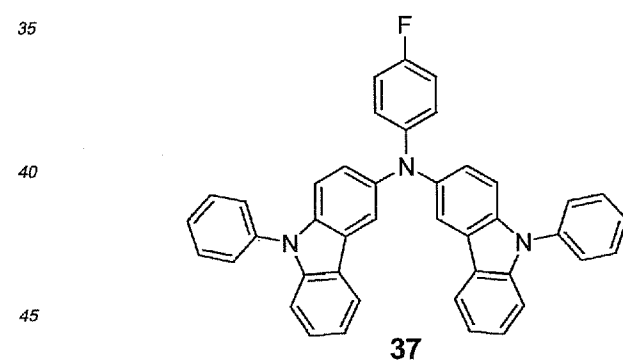
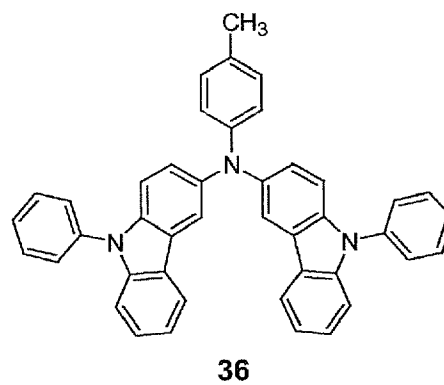
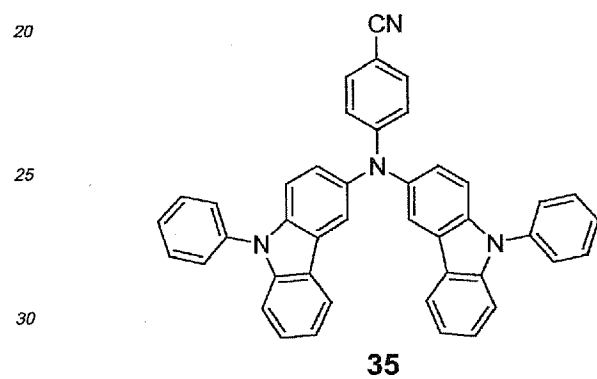
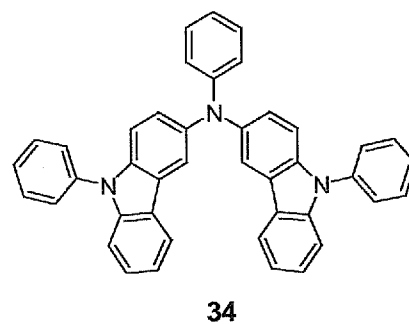
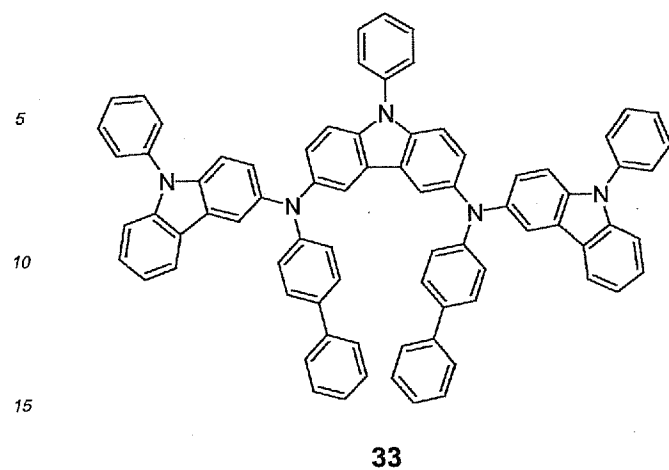






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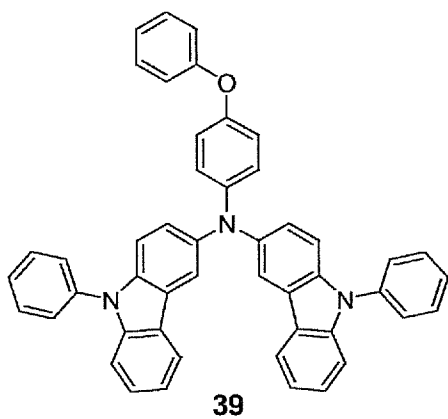
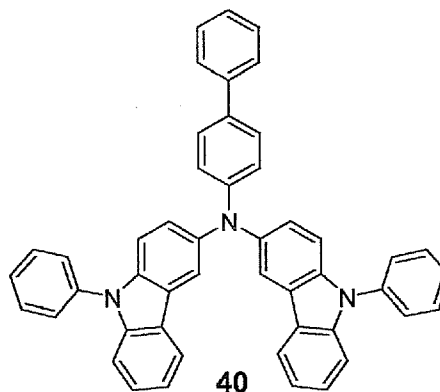
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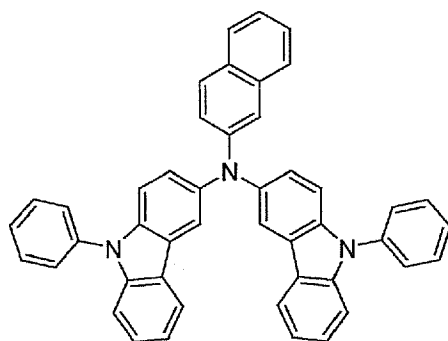
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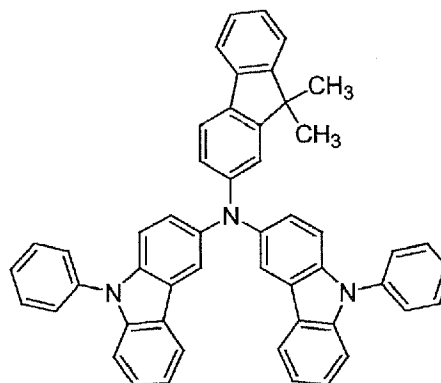
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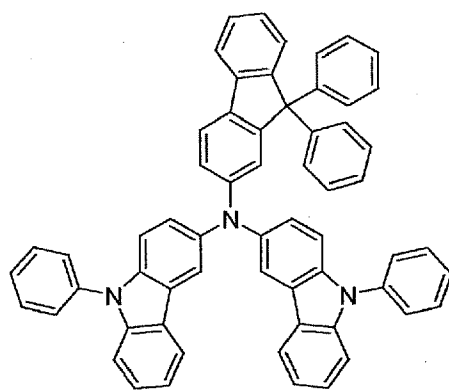
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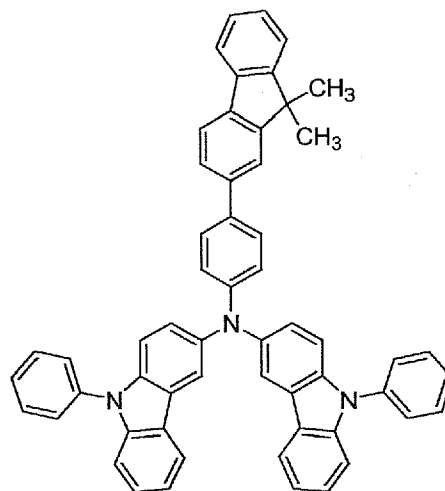
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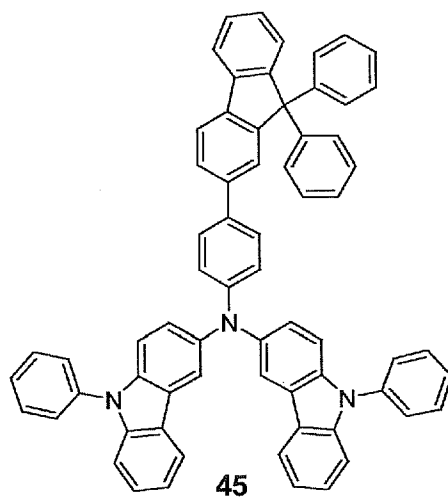
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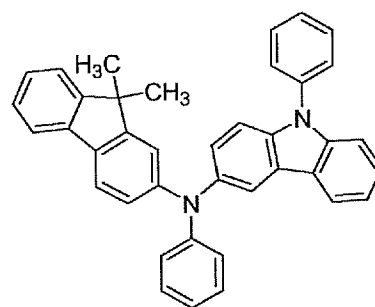
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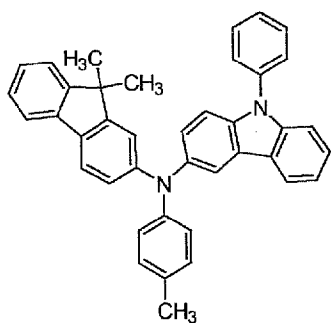
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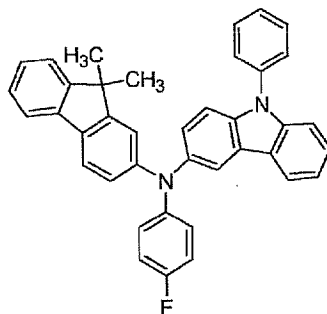
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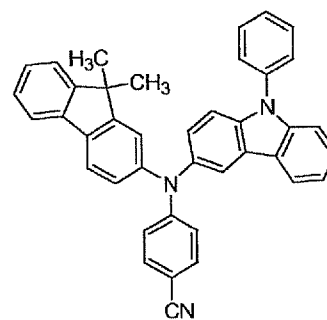
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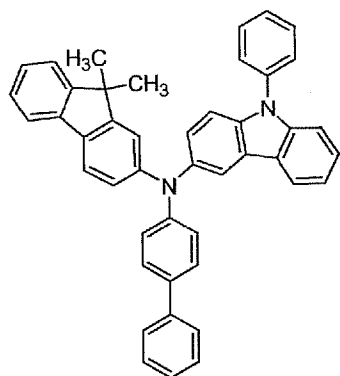
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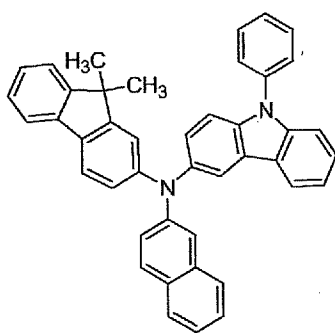
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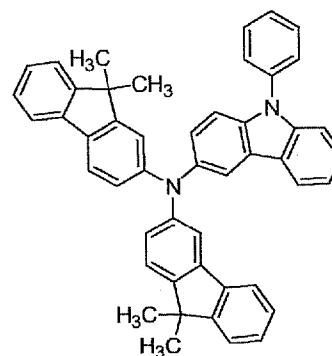
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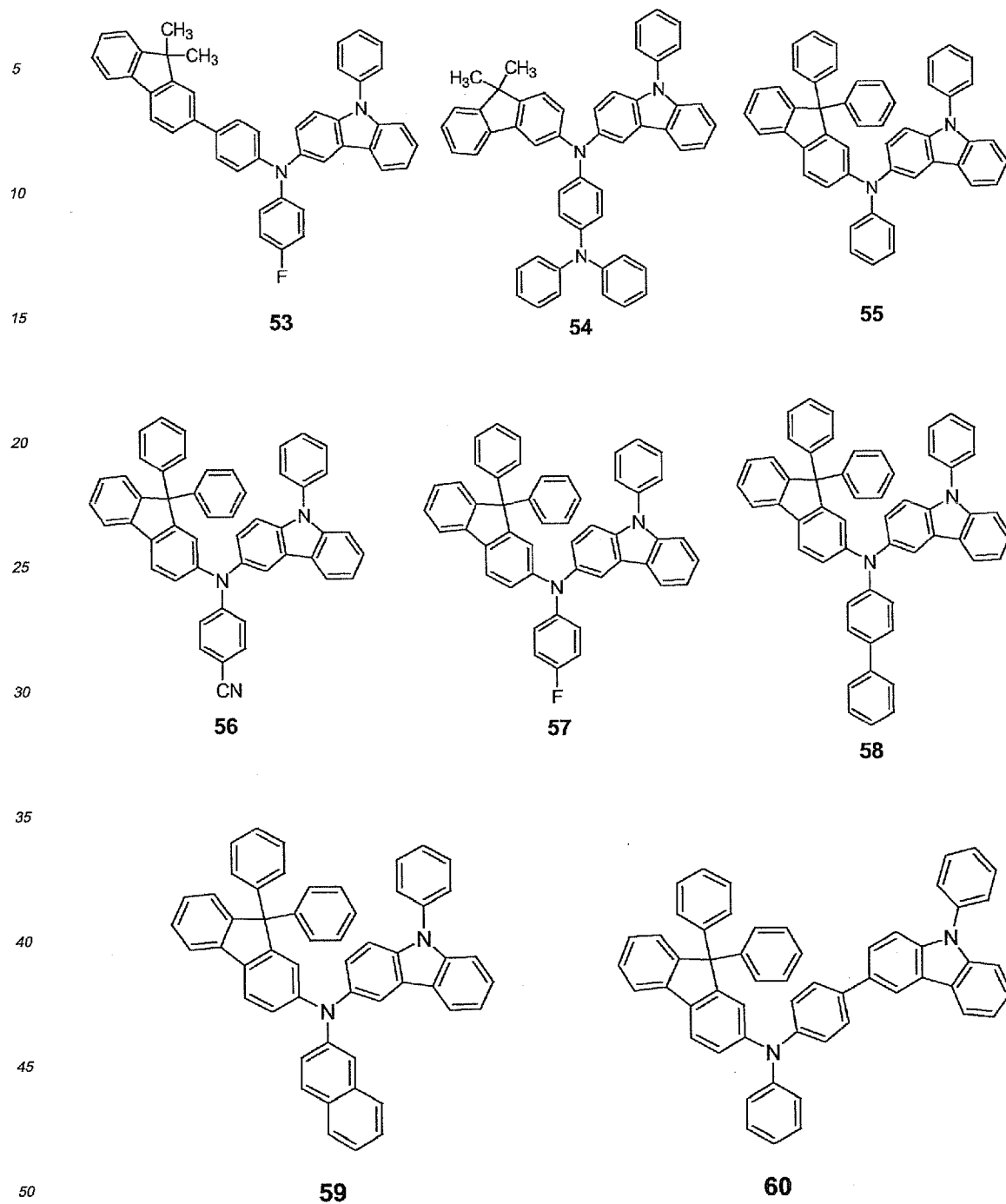
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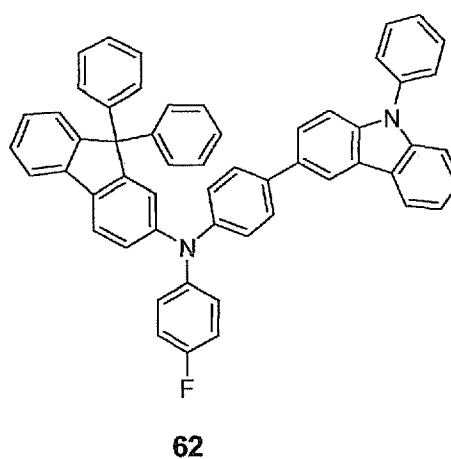
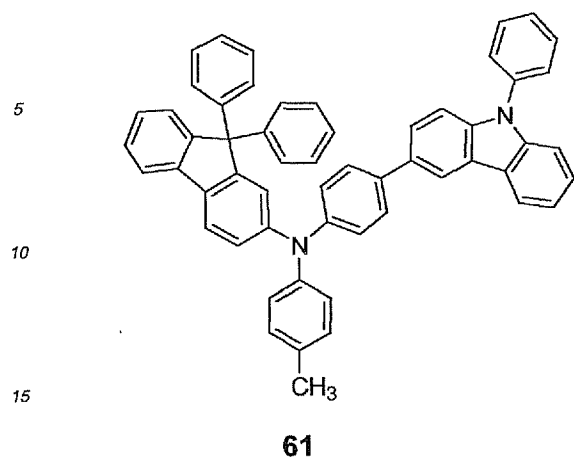


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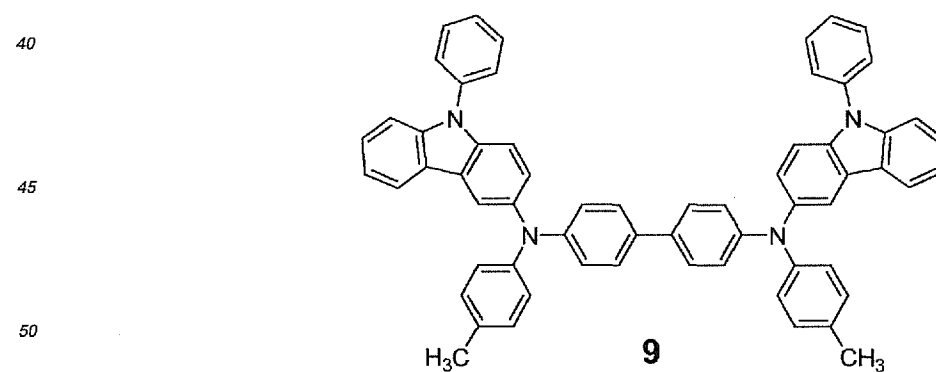
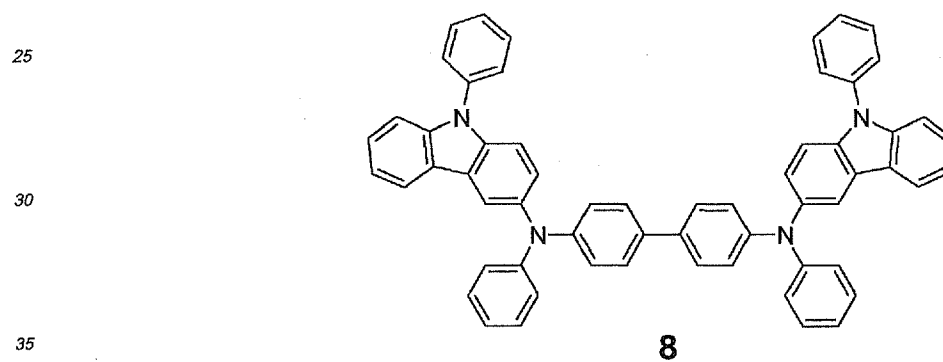


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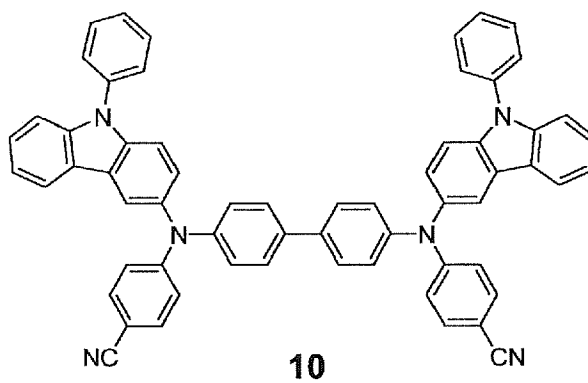
20 **19.** The organic light emitting device of claim 1, wherein the compounds represented by formulae (1), (2), and (3) are one of compounds 8, 9, 10, 11, 14, 28, 35, and 56:



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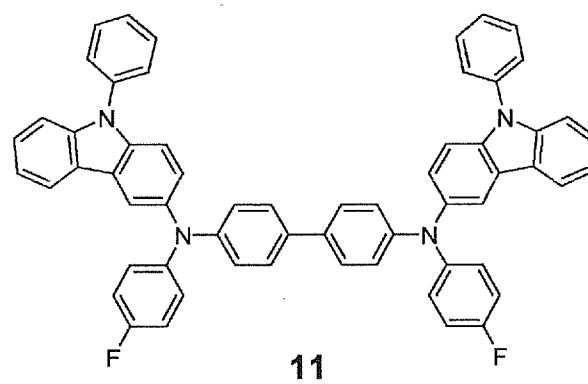
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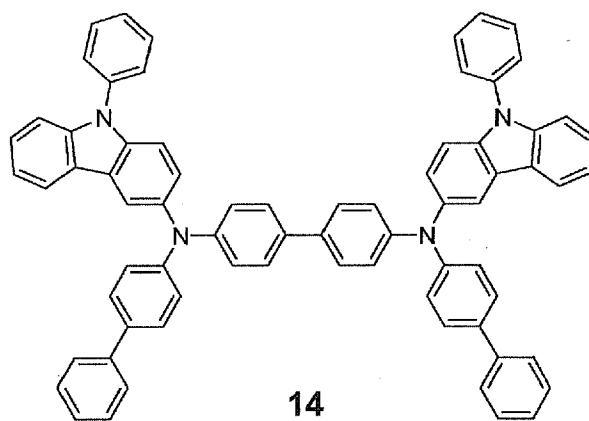
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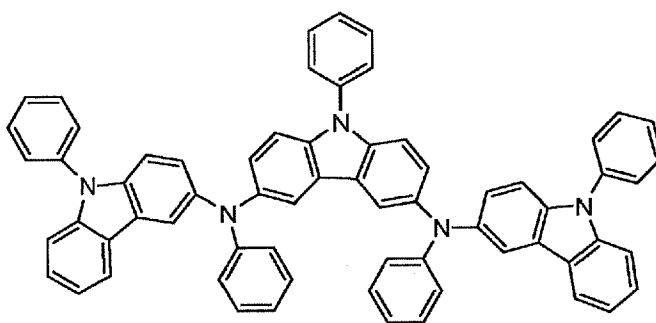
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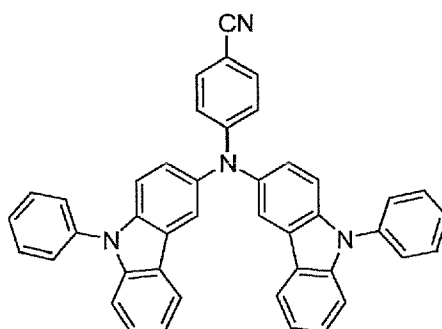


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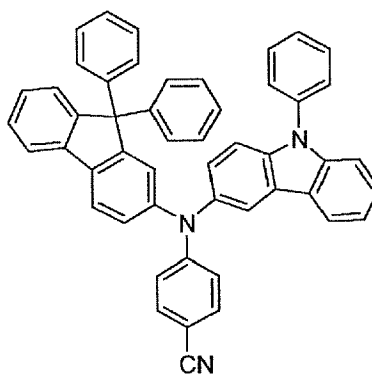
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20. The organic light emitting device of one of claims 1 to 19, wherein one of the first electrode and the second electrode is being a reflective electrode and the other is being a semitransparent or transparent electrode.
21. The organic light emitting device of claim 20, wherein the first electrode is formed on the substrate and is a reflective electrode, the second electrode is a semitransparent or transparent electrode.
22. The organic light emitting device of one of claims 1 to 21, wherein the organic layer comprising said at least one compound selected from the group of compounds represented by formulae (1) to (3) is one of a hole injection layer, a hole transport layer, and a single layer having hole injecting and transporting properties.

23. The organic light emitting device of claim 22, wherein the organic layer comprising said at least one compound selected from the group of compounds represented by Formulae (1) to (3) is a hole injection layer.
- 5 24. The organic light emitting device of claim 23, wherein the organic light emitting device further comprises an emission layer having a red emission region, and the thickness of a region of the hole injection layer formed under the red emission region is in the range of 1,600 to 2,200 Å.
- 10 25. The organic light emitting device of claim 23, wherein the organic light emitting device further comprises an emission layer having a green emission region, and the thickness of a region of the hole injection layer formed under the green emission region is in the range of 1,400 to 1,800 Å.
- 15 26. The organic light emitting device of claim 23, wherein the organic light emitting device further comprises an emission layer having a blue emission region, and the thickness of a region of the hole injection layer formed under the blue emission region is in the range of 1,000 to 1,400 Å.
- 20 27. The organic light emitting device of claim 23, wherein the organic light emitting device further comprises an emission layer having a red emission region, a blue emission region and a red emission region; the hole injection layer comprises a first region formed under the red emission region, a second region formed under the green emission region and a third region formed under the blue emission region; and the thickness of the first region is in the range of 1,600 to 2,200 Å, the thickness of the second region is in the range of 1,400 to 1,800 Å, and the thickness of the third region is in the range of 1,000 to 1,400 Å.
- 25 28. The organic light emitting device of claim 23, wherein the organic light emitting device further comprises a hole transport layer.
- 30 29. The organic light emitting device of claim 28, wherein the organic light emitting device further comprises an emission layer having a red emission region, and the total thickness of a region of the hole transport layer and the hole injection layer formed under the red emission region is in the range of 2,000 to 2,400 Å.
- 35 30. The organic light emitting device of claim 29, wherein the thickness of the region of the hole injection layer formed under the red emission region is in the range of 1,600 to 2,200 Å.
31. The organic light emitting device of claim 30, wherein the organic light emitting device further comprises an emission layer having a green emission region, and the total thickness of a region of the hole transport layer and the hole injection layer formed under the green emission region is in the range of 1,600 to 2,000 Å.
32. The organic light emitting device of claim 31, wherein the thickness of the region of the hole injection layer formed under the green emission region is in the range of 1,400 to 1,800 Å.
- 40 33. The organic light emitting device of claim 28, wherein the organic light emitting device further comprises an emission layer having a blue emission region, and the total thickness of a region of the hole transport layer and the hole injection layer formed under the blue emission region is in the range of 1,200 to 1,600 Å.
- 45 34. The organic light emitting device of claim 33, wherein the thickness of the region of the hole injection layer formed under the blue emission region is in the range of 1,000 to 1,400 Å.
35. A flat panel display comprising an OLED according to one of claims 1 to 34.
- 50 36. An organic light emitting device comprising:
 - a substrate;
 - a first electrode;
 - a second electrode, one of the first electrode and the second electrode being a reflective electrode, the other being a semitransparent or transparent electrode; and
 - 55 an organic layer interposed between the first electrode and the second electrode, the organic layer comprising an emission layer having a red emission region and a hole injection layer having a region formed under the red emission region, the thickness of the region or the hole injection layer formed under the red emission region being in the range of 1,600 to 2,200 Å.

37. An organic light emitting device comprising:

- a substrate;
- a first electrode;
- 5 a second electrode, one of the first electrode and the second electrode being a reflective electrode, the other being a semitransparent or transparent electrode; and
- an organic layer interposed between the first electrode and the second electrode, the organic layer comprising an emission layer having a green emission region and a hole injection layer having a region formed under the green emission region, the thickness of the region of the hole injection layer formed under the green emission
- 10 region being in the range of 1,400 to 1,800 Å.

38. An organic light emitting device comprising:

- a substrate;
- 15 a first electrode;
- a second electrode, one of the first electrode and the second electrode being a reflective electrode, the other being a semitransparent or transparent electrode; and
- an organic layer interposed between the first electrode and the second electrode, the organic layer comprising an emission layer having a blue emission region and a hole injection layer having a region formed under the
- 20 blue emission region, the thickness of the region of the hole injection layer formed under the blue emission region being in the range of 1,000 to 1,400 Å.

39. An organic light emitting device comprising:

- 25 a substrate;
- a pair of electrodes comprising a reflective electrode and a semitransparent or transparent electrode;
- an organic layer interposed between the reflective electrode and the semitransparent or transparent electrode, the organic layer comprising:
- 30 an emission layer having at least one or a red emission region, a green emission region and a blue emission region; and
- a hole injection layer having at least one of a first region formed under the red emission region, a second region formed under the green emission region and a third region formed under the blue emission region, the thickness of the first region being in the range of 1,600 to 2,200 Å, the thickness of the second region
- 35 being in the range of 1,400 to 1,800 Å, the thickness of the third region being in the range of 1,000 to 1,400 Å.

40. The organic light emitting device of claim 39, wherein the first electrode is formed on the substrate and is a reflective electrode, the second electrode is a semitransparent or transparent electrode, and the light generated in the organic layer is extracted through the second electrode.

41. The organic light emitting device of claim 39, wherein resonance occurs between the first electrode and the second electrode during the operation of the organic light emitting device.

42. The organic light emitting device of claim 40, wherein resonance occurs between the first electrode and the second electrode during the operation of the organic light emitting device.

43. A flat panel display device comprising the organic light emitting device of claim 39.

44. The flat panel display of claim 43, wherein one of the pair of electrodes of the organic light emitting device is electrically connected to a source electrode or a drain electrode of a thin film transistor.

FIG. 1

SECOND ELECTRODE
ELECTRON INJECTION LAYER (EIL)
ELECTRON TRANSPORT LAYER (ETL)
HOLE BLOCKING LAYER (HBL)
EMISSION LAYER (EML)
HOLE TRANSPORT LAYER (HTL)
HOLE INJECTION LAYER (HIL)
FIRST ELECTRODE
SUBSTRATE

FIG. 2

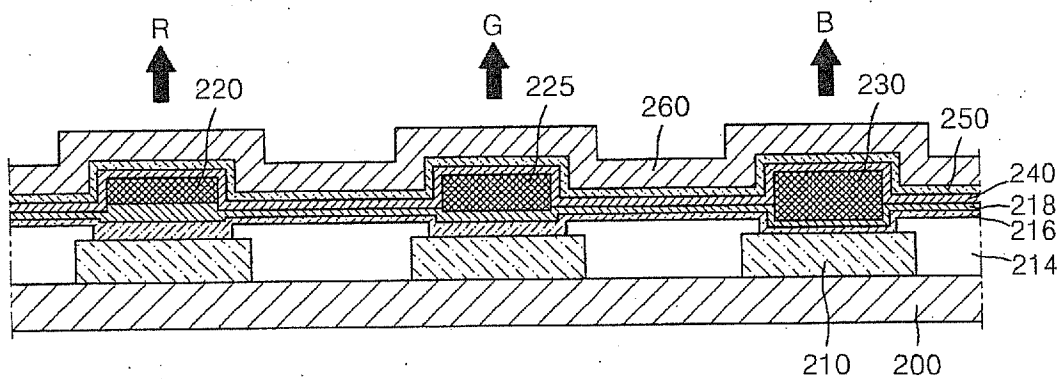


FIG. 3

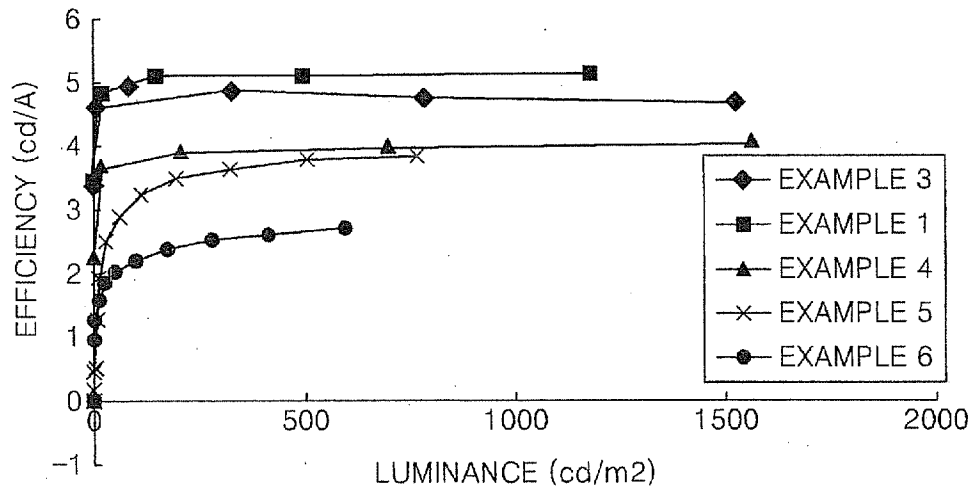


FIG. 4

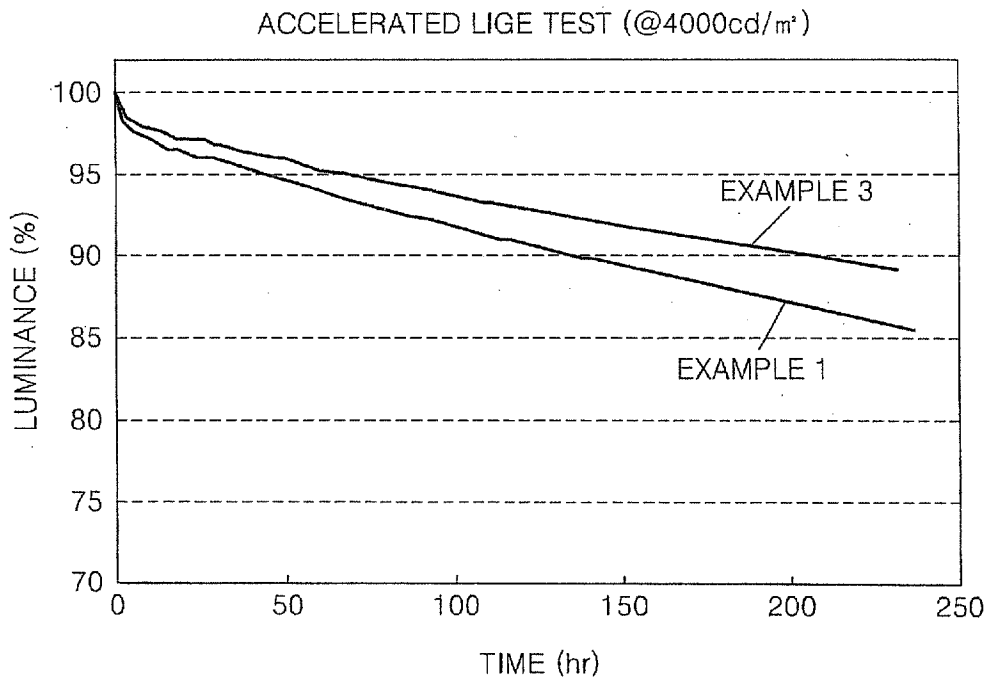


FIG. 5

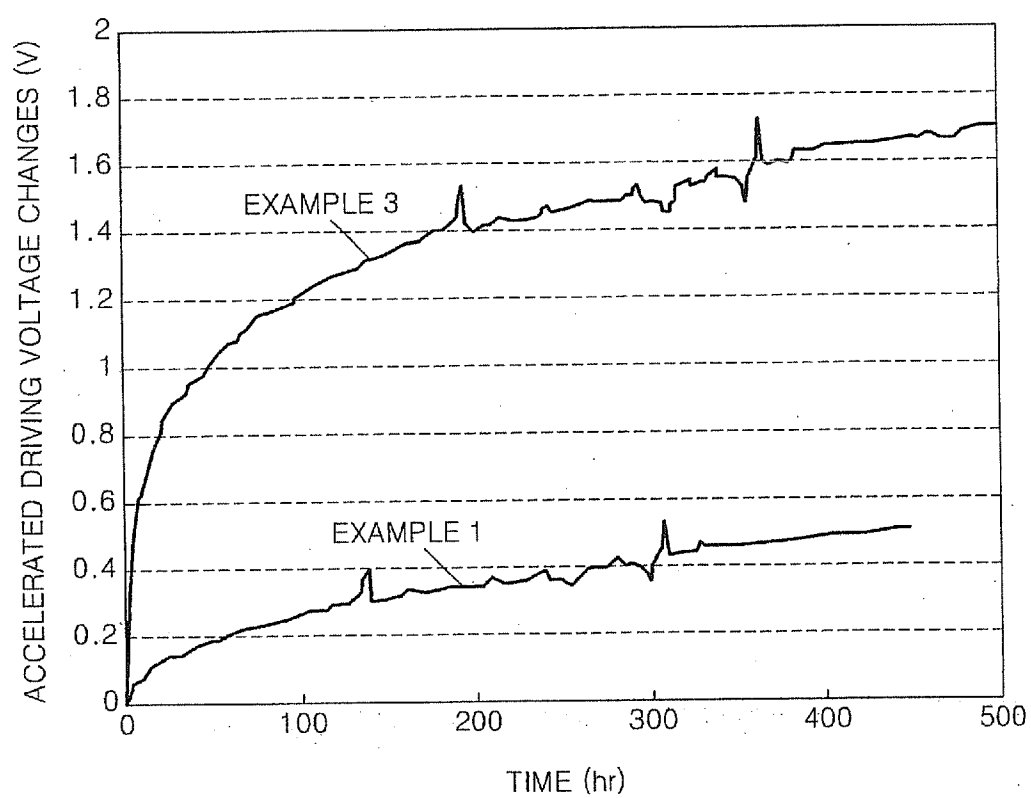


FIG. 6

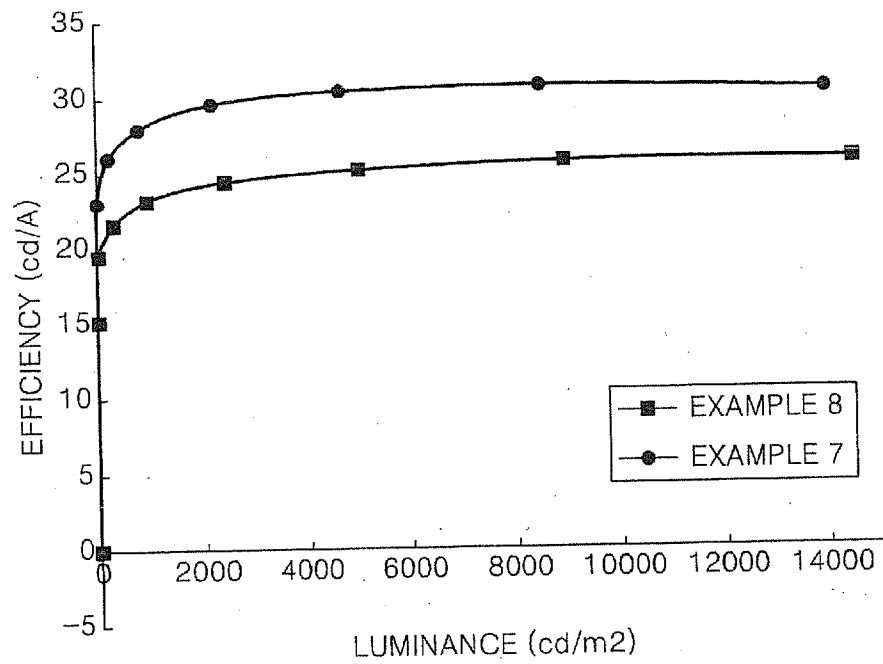
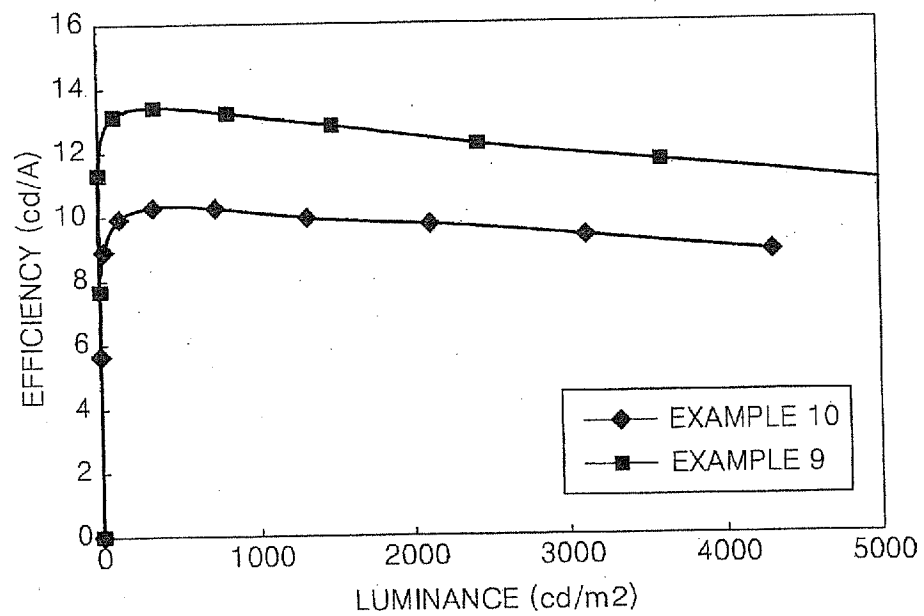


FIG. 7





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EUROPEAN SEARCH REPORT

Application Number
EP 07 10 9066

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A	* pages 4-8, compounds 1-24, Examples, claims *	27	
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A	* pages 4-7, compounds 1, 2, 4-24, pages 10-11, compounds 33-36, Examples, claims *	27	
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The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 8 October 2007	Examiner Nemes, Csaba A.
CATEGORY OF CITED DOCUMENTS		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document			

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EPO FORM 1503 03/02 (P04C01)



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EUROPEAN SEARCH REPORT

Application Number
EP 07 10 9066

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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The present search report has been drawn up for all claims			
Place of search		Date of completion of the search	Examiner
Munich		8 October 2007	Nemes, Csaba A.
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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EPO FORM 1503 03.02 (P04C01)



European Patent
Office

Application Number

EP 07 10 9066

CLAIMS INCURRING FEES

The present European patent application comprised at the time of filing more than ten claims.

- ☐ Only part of the claims have been paid within the prescribed time limit. The present European search report has been drawn up for the first ten claims and for those claims for which claims fees have been paid, namely claim(s):
- ☐ No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for the first ten claims.

LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

see sheet B

- ☐ All further search fees have been paid within the fixed time limit. The present European search report has been drawn up for all claims.
- ☐ As all searchable claims could be searched without effort justifying an additional fee, the Search Division did not invite payment of any additional fee.
- ☒ Only part of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the inventions in respect of which search fees have been paid, namely claims:
1-35, 39-44
- ☐ None of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims, namely claims:



European Patent
Office

LACK OF UNITY OF INVENTION
SHEET B

Application Number
EP 07 10 9066

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

1. claims: 1(part),2-6,18-35(part)

Organic light emitting device comprising an organic layer containing a compound of formula (1).

2. claims: 1(part),7-9,18-35(part)

Organic light emitting device comprising an organic layer containing a compound of formula (2).

3. claims: 1(part),10-17,18-35(part)

Organic light emitting device comprising an organic layer containing a compound of formula (3).

4. claim: 36

Organic light emitting device comprising an organic layer comprising an emission layer having a red emission and a hole injecting layer under the emission layer having a thickness of 1600 to 2200 Angstroms.

5. claim: 37

Organic light emitting device comprising an organic layer comprising an emission layer having a green emission and a hole injecting layer under the emission layer having a thickness of 1400 to 1800 Angstroms.

6. claim: 38

Organic light emitting device comprising an organic layer comprising an emission layer having a blue emission and a hole injecting layer under the emission layer having a thickness of 1000 to 1400 Angstroms.

7. claims: 39-44

Organic light emitting device comprising an organic layer comprising an emission layer having a red emission region, a green emission region and a blue emission region; and a hole injecting layer under the red, green and blue emission regions having a thickness of 1600 to 2200 Angstroms, 1400 to 1800 Angstroms and 1000 to 1400 Angstroms, respectively.

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 07 10 9066

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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08-10-2007

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

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